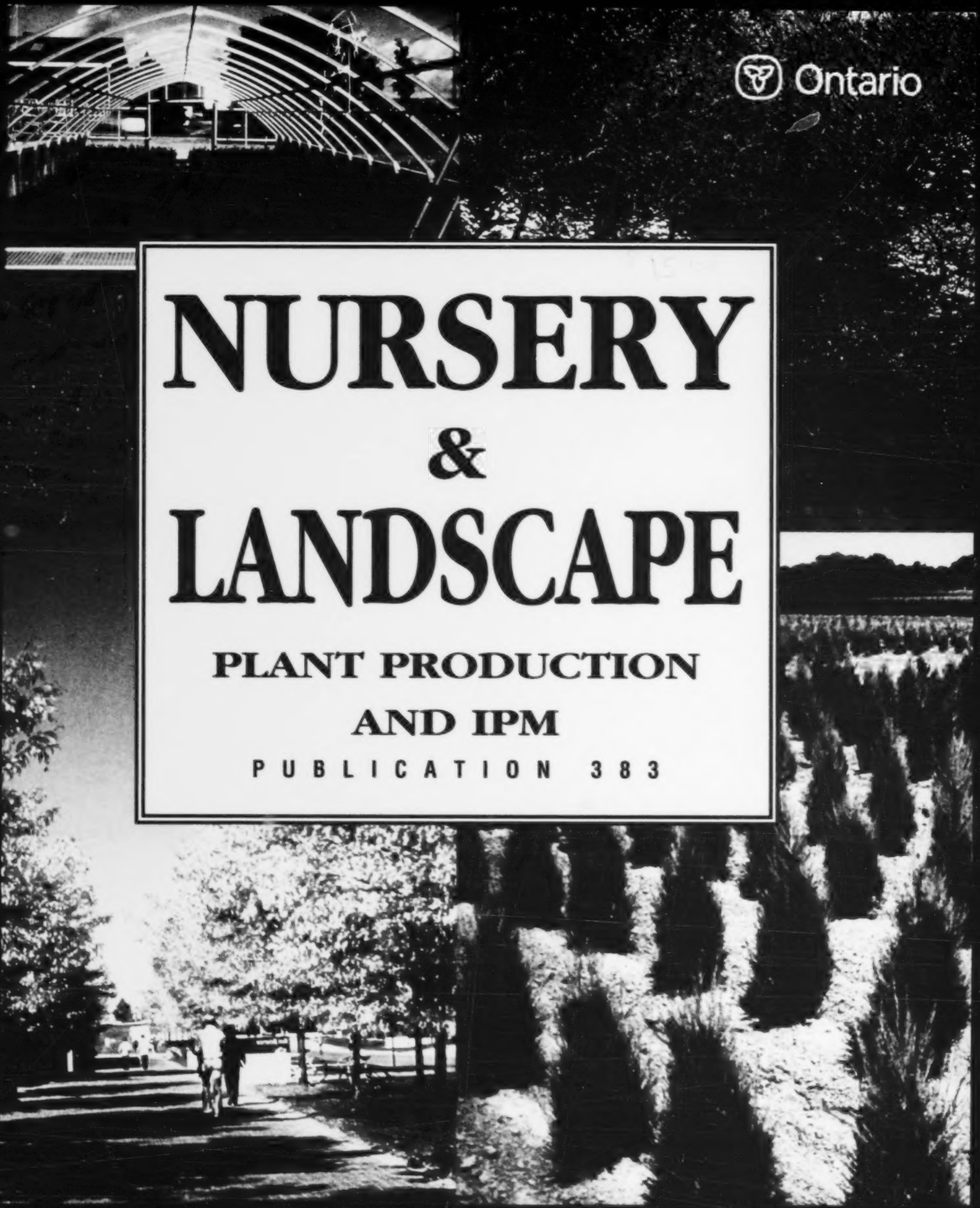
Ontario



NURSERY & LANDSCAPE

PLANT PRODUCTION AND IPM

PUBLICATION 383

MINISTRY OF AGRICULTURE AND FOOD

Recycle old editions of this publication. Each year the appropriate working group of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the committee, at the time of printing, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee (OPAC)
- classified by the Ministry of the Environment as of November 2002.

The information in this publication is general information only. By printing this publication, the Ministry of Agriculture and Food does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

The pesticide product label is a legal document. It is against the law to use the product in any other way. You must also use all pesticides in accordance with the *Pesticides Act* and Regulation 914, administered by the Ontario Ministry of the Environment.

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general the least hazardous materials and those pesticides that pesticide applicators have used satisfactorily for years are listed first. More toxic pesticides and/or newer ones with less practical grower experience follow.

This publication lists a number of brand names of pesticides. This is for your convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

Consult each product label for specific information such as compatibility with other materials and the effect of environmental conditions. Weather and other factors influence the effectiveness of pesticides and the likelihood of crop injury.

Health Canada has established maximum residue limits (MRLs) for pesticides. Processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply. Keep accurate and up-to-date records on pesticide use in each crop.

Federal Registration of Pesticide Products

The Pest Management Regulatory Agency (PMRA) of Health Canada grants registration following an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. **Full Registration**
   Pesticide registrations are normally granted for a period of five years, subject to renewal.
2. **Temporary Registration**
   Temporary registration may be granted for a period not to exceed one year, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

Supplemental Labels

You MUST obtain a supplemental label and follow all the label directions when PMRA approves new uses for a registered pesticide that do not appear on the current label.

Examples of when you must use a supplemental label include:

- **Temporary Registrations for Emergency Use**
- **Minor Use Label Expansion** (new label statements for crops that do not already appear on that product label).

You can obtain a copy of a supplemental label from the pesticide manufacturer or pesticide vendor, the grower association that sponsored the emergency registration or minor use, from OMAF or PMRA's Pest Management Information Service.

For more information on the federal registration status check the PMRA Web site at *www.hc-sc.gc.ca/pmra-arla* or call **1-800-267-6315.**

Regulation of Pesticides in Ontario

Classification of Pesticides into "Schedules"

The Ministry of the Environment classifies all pesticide products into one of six schedules, based on the potential hazards that product may have for human health and the environment. For up-to-date information on the regulatory status of any pesticide check the Ontario Pesticides Advisory Committee Web site at *www.opac.gov.on.ca* or call (416) 314-9230/ fax (416) 314-9237.

Licensing and Certification Requirements for Pesticide Users

You must be a certified grower or licensed exterminator to buy and use Schedule 1, 2 and 5 pesticides.

Requirements for Growers and their Assistants

Growers must be certified through the **Grower Pesticide Safety Course** to buy and use Schedules 1, 2 or 5 pesticides on land they farm. There must be at least one certified grower for each farm operation.

All agricultural assistants must also receive formal pesticide safety training, recognized by the Ministry of the Environment, before they can use Schedule 2 or 5 pesticides under the supervision of a certified grower. This applies to all assistants — including family members, farm employees and seasonal workers.

For more information about training for growers and agricultural assistants check the Ontario Pesticide Education Program Web site at *www.ridgetownc.uoguelph.ca/opep* or call 1-800-652-8573.

Requirements for Commercial Applicators and their Assistants

If you plan to apply pesticides as a business, you must be a licensed exterminator. **This includes farmers who custom apply pesticides for other farmers and charge a fee for this service.** You must complete a home study course and certification exam, and send proof of certification to the Ministry of Environment to obtain your license.

Unlicensed assistants must be Technicians before they may handle Schedule 2 (with restrictions), 3, 4 and 6 products under indirect supervision of a licensed exterminator. Technicians may not handle Schedule 1 and 5 products. For more information about exterminators and technicians check the Ontario Pesticide Training and Certification Web site at *www.ridgetownc.uoguelph.ca/optc* or call 1-888-620-9999.

Cette publication est aussi disponible en français.

Ontario

NURSERY & LANDSCAPE

PLANT PRODUCTION AND IPM

PUBLICATION 383

MINISTRY OF AGRICULTURE AND FOOD

Need technical or business information?

Contact the Agricultural Information Contact Centre at

1-877-424-1300

or

ag.info@omaf.gov.on.ca

Looking for pest control recommendations for woody landscape plants?

Phone the OMAF Nursery and Landscape Plant Agriphone Hotline
— it's udpated every Friday and it's TOLL-FREE.

1-888-290-4441 (for local calls 519-826-3414)

Looking for nursery and landscape plant information on the Internet?

www.gov.on.ca/omaf/english/crops/hort/nursery.html

It's one-stop shopping for factsheets, articles and photos regarding the production and maintenance of woody plants.

103-03544/

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1. Precautions with Pesticides

Pesticide Regulations

You must report all major spills, fires or thefts involving pesticides to the Ontario Ministry of the Environment at 1-800-268-6060. (*Regulation 914*, s. 29)

Pesticide Schedules in Ontario

The Ontario Ministry of the Environment reviews each pesticide product offered for sale in Ontario and classifies it into 1 of 6 groupings called Schedules.

Sch.	Who Can Use It	Pesticide Characteristics*
1	• licensed exterminator • certified grower • only with approved permit	• **very toxic** • very persistent • highly mobile
5	• licensed exterminator • certified grower • assistant agriculturist under supervision	• **very toxic** • very persistent • highly mobile • less toxic or less persistent alternative not available
2	• licensed exterminator • certified grower • trainee or technician under supervision of a licensed exterminator (some restrictions apply) • assistant agriculturist under supervision of a certified grower	• **toxic** • persistent • moderately mobile
3	• licensed exterminator • certified grower • trainee or technician • consumer	• **moderately toxic** • moderately persistent • slightly mobile
4	• licensed exterminator • certified grower • trainee or technician • consumer	• **low toxicity** • non-persistent • non-mobile • containers <1 kg <1 L
6	• licensed exterminator • certified grower • trainee or technician • consumer	• **low toxicity** • non-persistent • non-mobile • containers >1 kg > 1 L

Certification and Training Requirements

You must be a certified grower or a licensed applicator (exterminator) to buy and use Schedule 1, 2 or 5 pesticides. Assistants may also use these pesticides if they are trained and supervised as required.

Pesticide Certification for Ontario Farmers

Regulation 914 of the *Pesticides Act* requires that agriculturalists (growers) be certified to buy and use Schedules 1, 2 or 5 pesticides on land they farm. To become certified, agriculturalists must:

- attend the Grower Pesticide Safety Course (GPSC) and successfully complete the examination, and
- meet the definition of an "agriculturalist" as defined by Regulation 914 under the *Pesticides Act*, (i.e. use farm land for agricultural or forestry production, and that land falls within the farmlands property class under Section 7 of the *Ontario Assessment Act)*, and
- be at least 16 years of age.

Training for Agricultural Assistants Using Schedule 2 or 5 Pesticides

All assistants must have formal pesticide safety training that is recognized by the Ministry of the Environment, before they can handle or use Schedule 2 or 5 pesticides under the supervision of a certified grower.

- This applies to all assistants, including family members, farm employees and seasonal workers.
- Trained assistants do not have to write an exam.
- Trained assistants must be 16 years of age or older.

- There are 2 training options for assistants. Assistants can:
  - attend a grower pesticide safety course and not write the certification examination, an examination is not required, or
  - attend an on-farm training session presented by a qualified trained assistant instructor.

For more information and a listing of grower pesticide safety courses session dates and locations, check the Ontario Pesticide Education Program Web site at www.ridgetownc.uoguelph.ca/opep/.

To register for a grower pesticide safety course or anywhere in Ontario, or for information about trained assistants please:

- call: 1-800-652-8573
- fax: 1-519-674-1589
- e-mail: opep@ridgetownc.uoguelph.ca.

Certification and Licensing for Commercial Pesticide Exterminators

For updates to training requirements under Regulation 914 of the *Pesticides Act*, refer to the Ministry of the Environment Web site at www.ene.gov.on.ca/ or phone 1-888-565-4923.

You must be a licensed exterminator if you plan to apply pesticides as a business. This includes farmers who custom-apply pesticides for other farmers and charge a fee for this service. Licensed exterminators who are self-employed must hold an operator license as well as the appropriate exterminator license. Exterminator licenses are valid for 5 years.

To become a licensed exterminator, you must:

- successfully complete a home study course and certification exam through Ridgetown College, University of Guelph, **and**

- apply to the Ministry of the Environment to obtain your exterminator licence. You will need to send proof of certification (letter of successful completion of the exam(s)) and a fee. (See Appendix C, *Ontario Ministry of the Environment Pesticides Control Offices,* on page 131.)

Training for Technicians Working as Assistants to Licensed Exterminators

Assistants to licensed exterminators must become technicians to mix, load or apply all Schedule 3, 4 and 6 pesticides and most Schedule 2 pesticides (some restrictions apply), under the indirect supervision of a licensed exterminator. Technicians cannot mix, load or apply Schedule 1 or 5 pesticides. Technician cards are valid for 2 years. To become a technician, you must:

- complete an MOE-approved academic course and exam, **and**

- complete practical training with a licensed exterminator.

For more information about certification and licensing requirements for licensed exterminators and training for technicians, contact Ontario Pesticide Training & Certification:

- call: 1-888-620-9999
- fax: 519-674-1585
- Web site: www.ridgetownc.uoguelph.ca/optc.

General Precautions

Always read the label:

- Before you buy a pesticide!
- Before you begin to use a pesticide!
- Before you store a pesticide or dispose of it!

Learn about the health hazards and toxic properties of the pesticide you are using. Consult the product label, Material Safety Data Sheets (MSDS), or manufacturer for this information. Check the company Web sites for MSDS information.

Protect Yourself When You Use Pesticides

- **Make sure someone knows** where you are working, what pesticides you are handling and how long you expect the job to take.

- **Post emergency numbers**, including the Poison Information Centre and Spills Action Centre, near all telephones.

- **Keep a list of the names and the Pest Control Products (PCP) Act Registration Numbers of all pesticides you handle.** Keep a file of the pesticide label booklets for all products you use. Make sure your co-workers and family members know where this list or file is in case of an accident.

- **Have plenty of clean water, soap and paper towels and an extra set of gloves and coveralls nearby at all times** in case a pesticide contaminates your clothing or skin.

- **Wear the correct protective clothing and equipment, and be sure all items are clean and in good repair, before you put them on.**

- **Never smoke, chew tobacco, eat or drink when you handle pesticides.** Never carry tobacco or food in your clothes and never leave tobacco, food or beverages in areas where you handle or store pesticides.

- **Change your clothes and wash your hands and face before you eat, drink or smoke.**

- **Wash your hands *before* you use the toilet, as well as after.** The skin in your groin area absorbs pesticides very easily.

Protect Other People, Livestock, Pets, Water and Sensitive Crops

- Buy and store only what you need.
- Prevent drift.
- Keep pesticides out of water.
- Clean up spills quickly and safely.
- Dispose of containers and waste pesticide safely.

Human Health

Risk = Toxicity X Exposure

Risks of Pesticide Use

Each time you handle a pesticide, you are at some risk. The amount of risk depends on 2 things: the toxicity of that pesticide and your exposure to it.

Toxicity is a measure of how harmful or poisonous the pesticide is. There are 2 types of toxicity:

- **Acute toxicity** is the toxic response that results from a **single exposure** to the pesticide. The symbols and words on the front panel of a pesticide label give you information about the acute toxicity.

  Lethal Dose 50% (LD$_{50}$) is a measure of acute toxicity. It is the dose (mg of product/kg of body weight) that will kill 50% of the test animals within a stated period of time (24 hr, 7 days). **Those products with low LD$_{50}$ ratings are highly toxic.**

  Examples of products listed in this publication with a high acute toxicity include:

  azinphos-methyl (Guthion, Sniper)
  disulfoton (Disyston)
  endosulfan (Endosulfan, Thiodan)
  methomyl (Lannate)

- **Chronic toxicity** is the toxic response that results from **repeated exposures** to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do NOT give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

Cholinesterase Blood Tests

Organophosphorus and *carbamate* pesticides can affect your nervous system. These pesticides can change your serum and red blood cell levels of an enzyme called acetyl cholinesterase. Your body uses this enzyme to transmit messages through your nervous system. If your cholinesterase levels fall, you can experience symptoms including trembling, twitching, blurred vision, difficulty breathing and heart difficulties.

If you use any of the groups of pesticides listed below on a regular basis, you should have regular cholinesterase blood tests. Your family doctor can arrange these tests, which are covered by OHIP. **Have your first test *before* you begin to handle these pesticides.** That shows the baseline (normal) cholinesterase level for your body. During the spray season, if you are spraying organophosphorus or carbamate insecticides regularly for several weeks, have a cholinesterase blood test every **7–10 days**. If your cholinesterase level drops to below one-half of your baseline level, then you are showing signs of pesticide poisoning and **you must remove yourself from exposure** to these pesticides until your cholinesterase level returns to normal.

azinphos-methyl (Guthion, Sniper)
carbaryl (Sevin)
dimethoate (Cygon, Lagon)
disulfoton (DiSyston)
methomyl (Lannate)
phosmet (Imidan)
trichlorofon (Dylox)

Exposure is a measure of the contact you have with a pesticide. You can be exposed to a pesticide in 3 ways.

- **Dermal exposure** occurs through your skin or eyes. The amount and rate of pesticide that may be absorbed depends on several things, including:
  - your skin condition. If your skin is moist, or if you have rashes, broken skin or scratches, a pesticide will be absorbed more easily.
  - the part of your body that is exposed. Your eyes, genital area, scalp and ear canals absorb pesticides at a higher rate than your hands or arms. Your eyes absorb pesticides at a rate of 100%.
- **Respiratory exposure (inhalation)** occurs when you inhale small spray particles, dust, gases or vapours.
- **Oral exposure** occurs when a pesticide enters your mouth or you swallow a pesticide.

First Aid

1. Always protect yourself from injury first. Do not become another victim. Always put on protective clothing and equipment before you enter a contaminated area or handle a contaminated victim.

2. Check to see if the victim is breathing.

   If the victim is not breathing:
   - Straighten the victim's airway and check for breaths.
   - If the victim does not begin to breathe, administer artificial respiration until the victim begins to breathe on his/her own.
   - Do not contaminate yourself, especially if the victim has pesticide or vomit around his face or mouth. Use a face shield airway with a one way valve. Do not breathe the exhaled air from the victim.
   - Perform CPR if the victims pulse disappears. Only perform CPR if you are trained to do so.

   If the victim is breathing, but unconscious:
   - Place the victim in the recovery position (on the side with the head turned slightly to one side). If the victim vomits, try to keep the airway clear.

3. Stop the exposure to the pesticide. Move the victim away from the contaminated area. Remove all contaminated clothing. Use soap and water to wash any skin exposed to the pesticide.

4. Check the Four Basic Facts:
   - **Identify the pesticide**. Look for the label, container or leftover pesticide.
   - **Quantity**. How much product was the victim exposed to?
   - **Route of entry**. How did the pesticide enter the body? Did it enter through the mouth, skin/eyes or lungs?
   - **Time period.** How much time has passed since the victim was exposed to the pesticide, and how long was the exposure? Were the symptoms immediate or did the poisoning occur as a result of using the pesticide over a longer period of time?

Do not waste time. If you can not answer these questions quickly, be ready to tell emergency personnel whatever you can.

5. Call an ambulance or the Poison Information Centre.

6. Start the first aid treatment appropriate for the route of entry.

7. **Make sure the patient gets medical attention**. First aid is **not** a substitute for professional medical help.

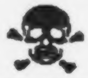
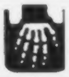
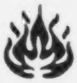
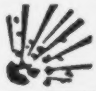
Emergency and First-Aid Procedures for Pesticide Poisoning (See inside back cover)

If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital. Take the pesticide label, MSDS sheet, or pesticide container with you. Do not transport the container in the passenger compartment of the vehicle.

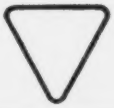
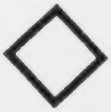
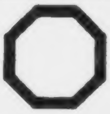
Pesticide Label Information

Know Hazard Symbols and Words

Four important symbols and words show the potential hazards of pesticides.

Hazard Symbol	Signal Word
	Poison
	Corrosive
	Flammable
	Explosive

The hazard symbol always appears inside one of the shapes shown below. These shapes and their warning words tell you the degree of hazard of the pesticide. **The greater the number of sides to the shape, the more hazardous the product**.

	Warning Symbol	Signal Word
Triangular shape means low hazard (3 sides)		Caution
Diamond shape means moderate hazard (4 sides)		Warning
Octagonal shape means high hazard (8 sides)		Danger

Learn these symbols and words — they could save your life!

Check the label for special warnings about eye hazards and skin hazards. The front panel of the pesticide label may also contain warnings that tell you the product is corrosive to eyes, or is a skin or eye irritant.

Re-Entry Periods

Re-entry period is the minimum amount of time that must pass between the time the pesticide was applied and the time that workers can go into the crop area without wearing personal protective equipment. If workers enter treated areas without wearing protective equipment too soon after pesticides have been applied they may experience poisoning. Such poisoning can result from handling treated plants or from inhaling pesticide vapours. The list below shows a specific minimum interval that you must observe between applying the pesticide and working in the treated crop without protective equipment.

24 Hours	48 Hours
methomyl (Lannate)	azinphos-methyl (Guthion, Sniper)

Some pesticides, like parathion, have labels that carry a warning about working in treated crops. **Follow the label recommendations.**

Days to Harvest (Preharvest) Intervals, Pregrazing and Feeding Intervals

These intervals state the minimum amount of time that must pass between the last pesticide application and the harvesting of the crop, or the grazing or cutting of the crop for livestock feed. If you harvest a crop before the preharvest interval has passed, there may be pesticide residues in excess of the Maximum Residue Limits (MRL) set by Health Canada.

To avoid exceeding the Maximum Residue Limits, always follow the label.

Crop Rotation Statements

Some pesticides can persist in treated soil and crops sensitive to that pesticide may be injured if they are planted too soon after the treated crop is harvested. Some labels state a minimum waiting time that must pass before it is safe to plant sensitive crops.

Total Number of Applications

Some product labels state the total number of applications of that pesticide that can be made during a growing season. These limits prevent food residues, crop damage, soil residues or pest resistance.

Buffer Zones

Buffer zones are areas left untreated to protect an adjacent area, for example a pond, a stream, a sensitive crop, a non-target crop, wetland or woodland, etc.

Protective Clothing and Equipment

Choose and Wear Appropriate Protective Clothing and Equipment

Make sure your protective clothing and equipment:

- is what you need for the job
- fits properly, and
- is clean and in good repair and working condition.

The protective clothing and equipment you need to wear depends on:

- **the pesticide you are using.** READ THE PRECAUTIONS SECTION OF THE LABEL TO KNOW WHAT TO WEAR.
- **the job you are doing.** For example, you need more protection when you handle concentrated pesticide, or when you mix and load your sprayer.
- **the type of application.** Enclosed space or air blast sprayer applications made with open tractors require more equipment.

Each person who is working with pesticides needs **their own** set of protective clothing and equipment. Consult the technical expert at your safety supply company to make sure that you purchase the appropriate equipment and that it fits the user.

For ALL pesticides, always wear:

- A water-repellent hat such as a hard hat or waterproof rain hat.
  - Where you need to protect your entire head and neck, for example applying pesticides in a greenhouse or applying dust formulations or using air-blast sprayers — wear a hood or hat that protects your ear canals.
  - Do not wear hats made from cloth.
  - Baseball-style caps absorb pesticides and are not safe.
- Long pants and a shirt with long sleeves, or a coverall.
  - Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Disposable coveralls should be designated for pesticide use.
  - Choose water-resistant coveralls. Cotton, denim and cotton-polyester fabrics can cling if wet and transfer pesticides to your skin. If you spill pesticide on your clothing, remove the clothing immediately.
- Chemical resistant gloves (unlined).
  - Use neoprene or nitrile gloves (PVC), unless the label states otherwise. **Do not** wear rubber gloves as many pesticides can break down the rubber material. Wear your gloves under your sleeves with the top cuffed.
- Chemical resistant boots (unlined).

Read the label. It describes what extra protective clothing and equipment to wear. For some pesticides you may also need to wear:

- goggles
  - Use safety goggles with indirect vents so splashes do not enter your eyes. Regular eyeglasses do not provide complete protection. Never wear contact lenses when you handle pesticides.
- face shield
- chemical resistant apron
- respirator
  - A respirator is a unit that covers your mouth and nose to prevent spray droplets, small particles,

and vapours from getting into your lungs. **A dust mask is not a substitute for a pesticide respirator.** When you buy a respirator or replacement cartridges, make sure the cartridges and prefilters protect you against organic vapours. For more information about respirators, refer to the *Grower Pesticide Safety Course manual*, Ridgetown College, University of Guelph.

You may need more protection, such as **Canister Gas Masks or Self-Contained Breathing Apparatus (SCBA)** when you apply:

- any pesticide in an enclosed area, or
- fumigants, gases, vapours or smokes.

ALWAYS wear a respirator when you work with fumigants, gases or vapours, or when you apply any pesticide in an enclosed area.

Use **Organic Vapour Tractor Cab Cartridges.** If you use a tractor with a cab when you spray, the tractor cab cartridges work the same as an air-purifying respirator. These cartridges and prefilters **must** be replaced and maintained regularly to provide continued protection.

When you use **air-blast sprayers and mist blowers and tractors without cabs**:

- wear the appropriate respirator, as well as a waterproof suit, head covering, chemical resistant gloves, boots, and eye protection. Once you complete the spray application, clean your protective equipment and the tractor. Do not operate the tractor without wearing protective clothing and equipment, unless it has been decontaminated.

Safety Supply Companies

Consult the safety supply company(s) of your choice for help in selecting your protective clothing and equipment. (See Table 1–1, *Safety Supply Companies in Ontario Providing Protective Clothing & Equipment*, on page 8.)

Care of Protective Clothing and Equipment

- After you complete the spray operation, clean all protective clothing and equipment.

- Never let children, pets or livestock come in contact with contaminated clothing or equipment. Make sure they do not come into contact with the puddles of water that result from cleaning your equipment.

- **Wash your gloves with soap and water, then *leave them on* to remove your other protective clothing and equipment.**

- Always remove protective clothing and equipment outdoors. If a granular pesticide was used, shake the clothing outdoors in a safe place, emptying pockets and cuffs.

- Throw out clothing contaminated by spills of highly toxic or concentrated pesticide. Place clothing in a plastic bag and take it to a landfill site.

- **Coveralls and other spray clothing must be washed separately from other clothes.** Wash after each use. Place them in a plastic bag and keep them separate.

- With your hands still protected by gloves, wash protective equipment. It is best to wash equipment outdoors. If you do not have an outside clean-up area, keep certain buckets just for equipment clean up. Mark them and keep them in a special place. Wash the inside and outside of your goggles, hat, boots, and any water-repellent clothing in warm soapy water, rinse well and let them air-dry.

- Remove the cartridges and prefilters from the respirator.

- Discard cartridges, canisters and filter pads when breathing becomes difficult, when you notice a pesticide taste or odour, or at the interval set by the manufacturer.

  – Note the date the cartridge is first used.
  – Remove cartridges and filter pads from the face piece and store in clean, sealed plastic bags.
  – Wash the face piece in warm soapy water, rinse thoroughly, and dry in a well-ventilated area. Air-drying prevents damage to the inlet and outlet valves.
  – Never use alcohol or other solvents for cleaning, as they damage the rubber and plastic.

- Next wash the outside of your boots and gloves with soapy water and remove them.

TABLE 1–1. Safety Supply Companies in Ontario Providing Protective Clothing & Equipment

3-M Canada Inc.	Occupational Health and Environmental Safety, Box 5757 London, ON N6A 4T1	(519) 452-6165 1-800-364-3577 Fax: (519) 452-4660
Acklands Grainger	90 W. Beaver Creek Rd. Richmond Hill, ON L4B 1E7	(905) 731-5516 1-800-668-8989 Fax: (905) 731-2798
Aearo Canada	7115 Tomken Rd. Mississauga, ON L5S 1X7	(905) 795-0700 1-800-387-4304 Fax: (905) 564-5250
Dutch Industries Protect-Air Cab Filter	Huron Tractor, Box 1300 Exeter, ON N0M 1S3	(519) 235-1115 Fax: (519) 255-1939
HAMISCO	3392 Wonderland Rd. London, ON N6L 1A8	(519) 652-9800 1-800-668-9800 Fax:(519) 652-9661
Kappler Canada	Box 1687 20 Ryan Place Brantford, ON N3T 5V7	(519) 752-4369 1-800-387-9326 Fax: (519) 752-2161
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	(905) 829-3299 1-800-668-6153 Fax: (905) 829-2919
MSA Canada Inc.	148 Norfinch Dr. North York, ON M3N 1X8	(416) 667-9400 1-800-267-0672 Fax: (416) 663-5908
Mitt & Robe Co.	751 Norfolk St. N. Simcoe, ON N3Y 3R6	(519) 428-4050 1-877-893-6565 Fax: (519) 428-5142
Plant Products Co. Ltd.	314 Orenda Road Brampton, ON L6T 1G1	(905) 793-7000 1-800-387-2449 Fax: (905) 793-9632
Safety Express	4060B Sladeview Cres., Unit 2 Mississauga, ON L5L 5Y5	(905) 608-0111 1-800-465-3898 Fax: (905) 608-0091
The St. George Company (Suppliers of Kasco Helmets)	P.O. Box 430 20 Consolidated Drive Paris, ON N3L 3T5	(519) 442-2046 1-800-461-4299 Fax: (519) 442-7191

- After removing boots and gloves, wash them inside and out with detergent and water, rinse thoroughly, and dry in a well-ventilated area.

- Place all dry articles in a clean storage area until next use.

How to Wash Your Spraying Clothes

Never mix spray clothing with household laundry. All clothing used for spraying must be stored and washed separately from other clothing. Wash after each use. Remember to use chemical resistant gloves to handle pesticide-contaminated clothing.

- Presoak clothing before washing. Use 1 of 3 methods:
  - hose-off garments outdoors
  - soak in separate tub or pail
  - use the prewash cycle in automatic washer.

- Place clothing directly into the washing machine. Wash only a few garments at a time. Do not wash with other family clothes.

- Use hot water, the highest water level, and the longest cycle, with heavy duty detergent. Wash as you would for heavily soiled clothing.

- Wash clothing again.

- After washing, hang outside (preferably in bright sunlight) until completely dry. Do not use the clothes dryer.

- Clean the washing machine. Run the washing machine through one complete cycle using only detergent and hot water. (No clothing.)

Personal Hygiene

- **Always wash your hands before eating, drinking or smoking.**
- **When you are finished for the day, take a bath or shower as soon as possible.** The longer a pesticide remains on your skin, the greater the risk it will be absorbed into your body.
- Wash your hair and under your fingernails. Shower with lots of soap and water.
- Always change into clean clothes.
- Wear clean work clothes every day. A small spill on the previous day's clothes may seem unimportant, but wearing the same clothing again without washing it prolongs the exposure and increases your risk.

Protect the Environment

Protect Water Sources

- You must use an anti-backflow device to prevent back siphoning when drawing water from wells, ponds, streams or other sources.
- Mix pesticide and load the sprayer **away** from any water supply, including wells, ponds or streams.
- Use buffer zones (untreated areas) when you apply pesticides to avoid contaminating surface water, wells, ponds and/or streams. Check the product label for specific buffer zone distances.

Reduce and Manage Pesticide Spray Drift

Spray only when winds are light to moderate. If you notice drift is occurring because of the wind, **stop spraying** until the wind subsides. Do not apply pesticides if the wind is blowing towards susceptible crops or environmentally sensitive areas such as watercourses.

- Read the product label for information regarding buffer zones, water volumes and recommended nozzles.
- Use buffer zones around all watercourses, wells and neighbouring fields that contain sensitive crops. If the label does not state a specific buffer zone distance, leave an untreated area of natural vegetation.
- Select the recommended sprayer application rate (L/ha).
- Select the correct nozzle. Where practical, use air induction/venturi nozzles. These nozzles significantly reduce drift when compared to conventional nozzles.
- Select the correct nozzle-to-target distance.
- Use spray-plume protection where practical or available (hoods, shrouds, screens and air curtains).
- Use drift-reducing adjuvants in the spray tank as directed by the label.
- Utilize wick weeders, instead of spraying, when possible.

For more information about spray drift consult OMAF/ Agriculture and Agri-Food Canada booklet *Best Management Practices Pesticide Storage, Handling and Application* and the Ontario Pesticide Education Program (Ridgetown College) videos *How to Manage Spray Drift* and *Spray Drift Reduction through Air Induction.*

Prevent Bee Poisoning

It is important to protect bees when you spray. Honeybees, as well as other bees and insects, are important pollinators of crops. Many crops also offer bees important sources of pollen for honey production.

If you choose to use insecticides for insect control, take these steps to prevent harming bees when you spray:

- Before you apply a pesticide, advise local beekeepers so that they can move colonies out of the danger area. Contact the Provincial Apiarist at 1-888-466-2372 for a list of the beekeepers in your area.
- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray after 7 p.m. when the bees are not foraging. If this is not a possibility, spray before 7 a.m. Bees usually do not forage at temperatures below 13°C.

- Do not apply insecticide on windy days to prevent drift toward any nearby hives.

- When there is a choice, choose the product formulation that is less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.

- Under the *Bees Act* it is an offence to spray in orchards while there is bloom on the trees.

Most organophosphate and carbamate insecticides are highly toxic to bees. Examples of insecticides used in crop production that are toxic to bees are listed below:

TABLE 1–2. Relative Toxicity of Insecticides to Honeybees

Group 1 – Very toxic. Do not apply to flowering crops or weeds	
Ambush	permethrin
Diazinon	diazinon
Cygon, Lagon	dimethoate
Furaden	carbofuron
Guthion	azinpho-methyl
Imidan	phosmet
Lannate	methomyl
Malathion	malathion
Ripcord	cypermethrin
Sniper	azinphos-methyl
Sevin	carbaryl
Group 2 – Apply only during late evenings or early morning*	
Decis	deltamethrin
Dylox	triclorfon
Endosulfan, Thiodan	endosulfan

* Usually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Read each pesticide label for specific precautions regarding bees.

Disposal of Pesticides and Empty Pesticide Containers

Triple or Jet Rinse Your Empty Pesticide Containers

Unrinsed pesticide containers are not really empty. They may still hold about 1% of the original amount of pesticide. Although this figure sounds low, it is still a hazard to humans, animals, and the environment. To reduce the hazard, rinse each container 3 times as the spray tank is filling. Use either the manual triple-rinse technique, or a specially designed device for rinsing containers. Paper or cardboard containers are often strong enough to be rinsed. If it is possible, rinse these containers as well as plastic ones.

To Triple Rinse

1. Fill the empty container at least 10% full with the diluting material (usually water).

2. Cap, then shake or roll the container so that the inside surfaces of the container are well rinsed.

3. Pour rinsings into the spray tank.

4. Repeat steps 1–3 twice more.

Remember to check the container after you have finished rinsing. Make sure no pesticide has been left behind as a cake or paste on the bottom of the container.

Rinsing Devices

Rinsing devices use pressurized water to clean the container. They are just as effective as triple rinsing but take less time. Follow the manufacturers instructions.

How to Dispose of Empty, Triple-Rinsed Containers

Never reuse empty pesticide containers. They may be handy, but there is still some risk, even if the containers are triple rinsed. Never give empty, rinsed containers to anyone, especially not children. Dispose of them promptly.

Regulation 914 of the *Pesticides Act* regulates how pesticide containers are to be disposed of in Ontario. [Reg. 914, s. 27]

For Metal, Plastic, or Glass Containers

Dispose of an empty metal, plastic, or glass container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide by triple rinsing or jet rinsing using clean water, or another appropriate solvent

AND either

- taking it for recycling to a pesticide container depot

OR

- taking it to a licensed waste disposal site.

Once properly rinsed, puncture the containers so they cannot be reused and to make sure the rinse water is totally out of the container.

It is often more convenient to store empty, rinsed containers until you have collected enough to make a trip to the recycling pesticide container depot or the waste disposal site. If you store containers, keep them in a dry safe place, such as the storage area, until you can dispose of them properly.

Recycling

The Ontario Pesticide Container Recycling Program is available to growers and commercial applicators. Through this program, **clean, triple rinsed, plastic/metal pesticide containers** (up to 23 L in size for plastic and 20 L in size for metal) can be returned to pesticide container depots located throughout the province. To locate the pesticide container recycling depot closest to you, call the Ontario Pesticide Education Program at 1-800-652-8573.

Future Farm Supply in Aylmer has a recycling pesticide container depot to collect empty metal drums that contained sucker oil and fumigants used in tobacco and fruit production.

For Paper and Cardboard Containers

Dispose of a paper or cardboard container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide by triple rinsing or jet rinsing (if possible) using clean water

AND either

- burning, (if allowed by municipal by-laws) in circumstances that persons and animals are kept out of any smoke produced and any smoke is directed away from buildings, highways, roads, or outdoor areas frequented by the public

OR

- taking it to a licensed waste disposal site.

Paper or cardboard containers are often rigid enough to withstand rinsing. If possible, triple rinse these containers as you fill the tank. Then burn the containers in an isolated area on your farm.

Be very careful around the smoke. It may contain toxic fumes from the burning pesticide. Be certain there is no chance that a person or animal may breathe in this smoke. Make sure the smoke does not drift toward buildings, roads, or any public outdoor areas.

These containers can also be taken to a local waste disposal site in the same way as metal, plastic, or glass containers. If you can't dispose of them immediately, make sure containers are kept in a secure place such as the pesticide storage area.

Unwanted Pesticides

If you have pesticides you do not need or cannot use, be sure to dispose of them safely.

- Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original container.

- If you cannot find any way to use the product as shown on the label, then the Ministry of the Environment requires that waste be disposed of by licensed waste haulers to a licensed waste disposal site. Look in the Yellow Pages under Liquid Waste Removal.

- Watch your local paper for Municipal Waste Collection Days or contact your municipality. If your municipality has no waste collection days, encourage them to sponsor such an event. On these days, you can turn over surplus pesticide concentrates (maximum 25 L) for disposal.

Surplus Spray Mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you can not find another field to spray, then dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. This diluted solution can be safely applied to the treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest, or surplus spray mix disposal.

NEVER respray the treated field with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause illegal pesticide residues in the harvested crop or harmful residues in the soil that can cause crop damage.

Soluble Packaging Options

Choose soluble packages that dissolve in the spray tank to reduce container disposal. Water-soluble packaging is used for dry flowable and wettable powder formulations of pesticides and is available under names such as Clean Pak, Solupak, and Toss-N-Go. In most cases, the water-soluble packaging material is PVA (polyvinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Read all labels and instructions carefully. For more details contact your vendor.

Storing Pesticides

Ontario's *Pesticides Act* and Regulation 914 give storage requirements for storage facilities. The storage requirements you must follow depend on which Schedules of pesticides you store.

Pesticide Spills

Protect yourself before you begin to clean up any spill. Clean up spills immediately.

In the case of minor spills:

- for liquids, cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum.
- for powders and granulars, sweep or shovel the material into a waste drum.

In the case of a major spill:

- **remove any people or animals from the spill area**
- stop the spill from spreading
- do not let the pesticide enter any watercourse.

For information on preventing spills see OMAF Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025.

Pesticides Act **Storage Requirements**

	Sch. 3, 4 & 6	Sch. 2	Sch. 1 & 5
No contact with food or drink	◆	◆	◆
Not impair health/safety	◆	◆	◆
Clean & orderly manner	◆	◆	◆
Warning signs posted on storage buildings	◆	◆	◆
Warning signs posted on unattended vehicles	◆	◆	◆
Emergency telephone numbers posted	◆	◆	◆
Ventilated to outside		◆	◆
Limited access (locked)		◆	◆
No floor drain		◆	◆
Safety equipment available		◆	◆
Area used exclusively for pesticides			◆

If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of the Environment, Spills Action Centre at 1-800-268-6060 (24 hours a day, 7 days a week) and the municipality.

Application Procedures

Sprayers

- Sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides.
- If 2,4-D or related herbicides are used, clean the sprayers thoroughly with detergent containing ammonia to prevent crop damage.
- Adequate agitation is essential when applying wettable powder formulations.
- Pumps should be capable of delivering the flow and pressure required as well as being compatible with materials sprayed.
- Keep in mind that the higher the pressure, the greater the danger of drift to other crops.
- Calibrate your sprayer at least twice during the growing season with each set of nozzles used. The wear on nozzles and other parts will alter the amount of spray delivered.
- Check all nozzles for flow rate at least once a year. Replace nozzles when their output is 10% greater than rated output.
- For information on calibration, see the current OMAF Publication 75, *Guide to Weed Control.* See calibration calculator on the OMAF Web site.

General Precautions and Requirements for Fumigants (Gases, Vapours and Fumes/Smokes)

Read and follow all instructions on the product label regarding protective clothing and equipment, aeration of treated areas, and re-entry periods.

- Lock the building and post warning signs.
- If you use a fumigant gas, such as methyl bromide plus chloropicrin to fumigate soil, you must hold the appropriate structural license, (i.e. Fumigation General or Fumigation Soil) and you may require a permit issued under Ontario's *Pesticides Act.* To apply for a permit, contact the regional pesticides officer with the Ontario Ministry of the Environment.
- As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation. (This is a requirement for all fumigant gas use.)
- Do not wear gloves when you handle methyl bromide. You must wear a self-contained positive pressure breathing apparatus.
- When you handle aluminum phosphide, use cotton gloves and wear a full-face mask respirator with an acid gas canister, or a self-contained positive-pressure breathing apparatus.

For more information, obtain *Structural Fumigation Procedures* (September 1998 edition) and/or the *Permit Guide for Structural Fumigation* from the Ontario Ministry of the Environment.

Band Spraying

Check the product label under Directions for Use. Some labels give specific nozzle recommendations and formulas to determine band application rates.

You need to decide how much spray mix to prepare so that you will apply the recommended rate over the band area. To know how much to mix, you will first need to calculate the size of the entire treated area.

To calculate the total area of all the treated bands:

$$\underset{\text{(ha or acres)}}{\text{Total Band Area}} = \underset{\text{(ha or acres)}}{\text{Total area of Planted Field}} \times \frac{\text{Band Width (cm or in)}}{\text{Row Spacing (cm or in)}}$$

Seed Treatments

Remember that seed treatment products are also pesticides.

- Seed dressings and seed treatments are poisonous to people and animals.
- Wear protective clothing and equipment when you are treating seed, or handling treated seed. Protect your skin — wear a long-sleeved shirt and long pants or coveralls and wear neoprene or nitrile gloves. Protect your eyes with goggles and/or a face shield. Wear a respirator to protect your lungs from dusts and vapours.

- Wash thoroughly after finishing the treatment, or handling the treated seed.

- Never feed treated seed to animals.

- Keep treated seed out of the reach of children.

- Destroy all the bags that have held treated seed as recommended in the container disposal section by burning or by taking to a licensed waste disposal site.

Aerial Application by Airplane or Helicopter

Any person who applies pesticide from an aircraft in Ontario must hold an Aerial exterminator licence. In addition, a permit is required to purchase and apply pesticides by air for the following:

- applications to forests as defined in the *Crown Forest Sustainability Act*
- applications of any Schedule 1 or 5 pesticide or a Schedule 2 pesticide containing 2,4-D, 2,4-DB, mecoprop, MCPA, MCPB, dichlorprop, dicamba, picloram, paraquat or trichlopyr.

Be sure that any pesticide you apply by air has specific instructions for aerial use on the label. Take extra precautions when using insecticides applied by air that are toxic to honeybees, such as Sevin (carbaryl).

2. Managing Soil Fertility

Fertilizers, when used correctly, produce high crop yields at a minimal cost. Always apply fertilizers at a rate consistent with soil fertility as measured via OMAF-accredited testing (see below). Low fertility soils may need nitrogen, phosphorus, potassium and micronutrients at levels at least equal to what the crop removes. However, high fertility or heavily manured soils may not benefit from added fertilizer due to increased costs and possibly reduced yields.

The OMAF-Accredited Soil Testing Program

The OMAF-Accredited Soil Testing Program enables you to determine the optimum fertilizer and lime application for crop production. Use this program along with plant analysis and observation of plant nutrient-deficiency symptoms to determine your fertilizer requirements for a specific crop on a specific field.

The program recommends the phosphate, potash and magnesium fertilizers, plus the type and amount of lime, appropriate for your soil. The OMAF-recommended application rates provided in this publication should produce the highest possible economic yields when accompanied by good management practices. Research shows that higher application rates will sometimes produce higher yields, but the increase is likely to be small and unprofitable.

Soil Tests from Unaccredited Laboratories

Be sure to use an accredited testing service. To be accredited, a laboratory must use OMAF-approved testing procedures, demonstrate acceptable analytical accuracy and precision, and provide the OMAF fertilizer recommendations.

Some farmers ask OMAF staff to interpret results from unaccredited laboratories. If the laboratory correctly uses tests identical to those used by OMAF-accredited laboratories and expresses their test results in the same units, the OMAF fertilizer requirements for *phosphate* and *potash* can then be determined.

Unaccredited Soil Tests

Soil tests such as exchange capacity, aluminum and copper are not accredited by OMAF because these tests do not contribute to better fertilizer recommendations. For example, research shows that on Ontario soils using exchange capacity to adjust potash recommendations can reduce the reliability of the recommendations.

See Table 2–1, *OMAF-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories,* page 16, for a list of laboratories accredited to perform soil tests on Ontario soils and to analyze plant and greenhouse media samples. Please note that these labs may also offer water testing services, but these tests are not accredited by OMAF to date.

Field Soil Culture

When to Sample Field Soil

Always allow enough lead time for a soil analysis. Take soil samples the previous fall from fields to be fertilized in the spring. You may, for convenience, sample earlier in the season. If you sample for the next year during the previous summer you can avoid the rush of harvest and the likelihood of bad weather in late fall.

How to Sample Field Soil

It is important to sample your soil correctly.

- Use a *sampling tube* or a *shovel* to sample soils.
- Sample each field or uniform section of a field, separately.

TABLE 2–1. OMAF-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories

A & L Canada Laboratories East	Soil, leaf	2136 Jetstream Road London, ON N5V 3P5	Tel: (519) 457-2575 Fax: (519) 457-2664 www.al-labs-can.com aginfo@al-labs-can.com	Ian McLachlin Greg Patterson
Accutest Laboratories	Soil, leaf	146 Colonnade Road Unit #8 Nepean, ON K2E 7Y1	Tel: (613) 727-5692 Fax: (613) 727-5222 www.accutestlabs.com phaulena@accutestlabs.com	Peter Haulena Rob Walker Lorna Wilson
Agri-Food Laboratories	Soil, leaf, greenhouse media	503 Imperial Road Unit #1 Guelph, ON N1H 6T9	Tel: (519) 837-1600 or 1-800-265-7175 Fax: 519-837-1242 www.agtest.com lab@agtest.com	Dale Cowan Nora Howlett
Brookside Laboratories Inc.	Soil	301 South Main St. New Knoxfille, Ohio 45871	Tel: (419) 753-2248 Fax: (419) 753-2949 nfisher@blinc.com	
Soil and Nutrient Lab, University of Guelph	Soil, leaf	P.O. Box 3650 95 Stone Road West Guelph, ON N1H 8J7	Tel: (519) 767-6306 or (519) 767-6226 Fax: (519) 767-6240 vkerslak@lsd.uoguelph.ca	Nicole Fisher Mark Flock
Stratford Agri Analysis	Soil, leaf	1131 Erie Street Box 760 Stratford, ON N5A 6W1	Tel: (519) 273-4411 or 1-800-323-9089 Fax: (519) 273-4411 saa@dacolabs.com	Keith Lemp Dale Peters

- Take at least 20 soil cores from 15 cm deep from any field or area up to 5 ha in size. Take proportionately more cores from fields larger than 5 ha. One sample should not represent more than 10 ha. The more cores you take, the more likely your soil sample will reliably measure the field's fertility.

- Traverse each sampling area in a zigzag pattern to distribute the sampling sites uniformly.

- Sample separately all parts of a field where soil or crops look different or were previously fertilized, manured, or limed differently — even if these areas are too small to fertilize separately in the future.

- Do not sample recent fertilizer bands, dead furrows, areas adjacent to gravel roads, or areas where lime, manure, compost or crop residues have been piled.

- Collect the soil in a clean pail.

- Break up the lumps and mix the soil thoroughly.

- Forward the soil in a *soil sample box* for testing.

- Sample each field once every 2 or 3 years.

- Be sure to enclose a *field information sheet* with every soil sample.

Field Soil Management Practices

Good soil management practices play a major role in ensuring a profitable crop yield. Information about the field, the crop to be fertilized, manure application and legume sod plowed down is essential for a reliable fertilizer recommendation. Record it on the *field information sheet* that must accompany each soil sample sent for analysis.

Field Soil Micronutrient Testing

OMAF offers accredited tests for *manganese* and *zinc*. Use these tests in conjunction with visual deficiency symptoms and plant analysis. OMAF-accredited tests are not available for boron, copper, iron or molybdenum.

- Manganese availability decreases with increasing soil pH. Do not add more lime to your soil than is needed to correct acidity.

- Control zinc deficiency by preventing soil erosion and using animal manures. If necessary, prompt use of zinc fertilizers and foliar sprays can reverse zinc deficiencies after symptoms appear.

- If a zinc soil test value exceeds 200, suspect zinc contamination of the sample or field.

How to Sample Field Soil Micronutrients

It is important to sample your soil correctly. See *How to Sample Field Soil*, page 15, for soil sampling instructions.

- Micronutrient deficiencies often occur in small patches. In these cases, soil and plant samples taken from the entire field may not reveal the problem. It is best to sample every problem area separately.
- Micronutrients, especially zinc, easily contaminate soil samples. Take great care to prevent any sample contamination. Never use galvanized (zinc plated) sampling tubes to take soil samples for micronutrient tests. A soil sample that contacts a galvanized surface cannot be used for testing.
- Do not collect and mix samples in metal containers. Use clean plastic containers in good condition.
- Be sure that no environmental dust or dirt (e.g. from around buildings) contaminates your samples.

Foliar Analysis (Plant Tissue Testing)

Foliar analysis is the best way to diagnose micronutrient problems. It measures the nutrient content of plant tissue. OMAF uses foliar analysis to diagnose suspected nutrient disorders in field-grown and container-grown nursery stock.

When to Sample Plant Tissues

Nutrient levels vary widely with plant age. It is best to take plant tissue samples in July or August. At other times, sample plant tissues if visual symptoms appear.

How to Sample Plant Tissues

It is important to sample plant tissues correctly.

- From deciduous trees and broadleaf evergreen shrubs, select approximately 50 fully expanded leaves midway along a shoot of the current season.
- From conifers, select 15–20 (10 cm) shoots of current season growth. Remove the needles and discard the twigs of pine, spruces and fir.
- Rinse dirty foliage in distilled water.
- Deliver fresh plant materials directly to the laboratory. If not delivered immediately, always air-dry the tissue samples and ship them in paper bags to avoid spoilage.
- Submit a sample of healthy leaves from the same area to allow comparisons.

See Table 2–1, page 16, for a list of labs and the tests provided by each one.

Soil pH Testing

pH measures soil acidity or alkalinity on a scale from 0 to 14. The midpoint of the scale, 7, is neutral. Values below 7 are increasingly more acid, while values above 7 are increasingly more alkaline. In general, we use *lime* to raise pH (making the soil more alkaline) and *sulphur* to lower pH (making the soil more acid). Soil pH testing helps you determine any necessary pH adjustments.

Issues Surrounding pH

- Iron and manganese solubility increases with increasing acidity. Many other elements become less available as soil pH drops below 6.0.
- Most nursery stock grows well between pH 5.0 and pH 7.2.
- Plants such as red maple, pine, oak, tuliptree and euonymus may exhibit iron and/or manganese chlorosis if the pH is above 7.0.
- For ericaceous plants and conifer seed beds, the pH should be below 6.5.

Table 2–2 specifies normal foliar nutrient concentrations for nursery stock. Established landscape stock nutrient concentrations may be somewhat lower.

TABLE 2–2. Average Foliar Nutrient Content of Healthy Nursery Stock

Nutrient	N %	P %	K %	Ca %	Mg %	Mn ppm	Cu ppm	Zn ppm	B ppm	Fe ppm
Field Grown										
Conifers	1.7	0.24	1.0	1.0	0.2	88	6	31	35	87
Broadleaf Evergreens	2.3	0.27	1.1	2.5	0.3	25	5	27	42	120
Deciduous Trees and Shrubs	2.8	0.25	1.7	2.4	0.4	62	7	25	58	133
Container Grown										
Conifers & Broadleaf Evergreens	2.5	0.4	1.4	2.0	0.3	52	5	24	48	127

- Long-term use of fertilizers such as ammonium sulphate, ammonium nitrate, urea, potassium sulphate and mono-ammonium phosphate will gradually reduce soil pH. This is most likely with light, sandy soils and can be corrected by liming the soil.

- Anhydrous ammonia causes a marked, though temporary, soil pH increase when first applied.

- Superphosphate and muriate of potash have little or no effect on soil pH.

Buffer pH Testing

pH adjustments depend on the clay and organic matter content of each soil. Different soils with identical pH values will require different amounts of lime or sulphur to reach a desired pH level. Where soil is too acid, an additional soil test, the *buffer pH*, determines the amount of lime required to increase pH appropriately.

Limestone Type

You can apply *calcitic limestone* or *dolomitic limestone* to your soil. Calcitic limestone is mainly calcium carbonate, while dolomitic limestone is a mixture of calcium and magnesium carbonates.

- When the magnesium in your soil is 100 ppm or less, use dolomitic limestone. It is an excellent, inexpensive magnesium source for acid soils.

- When the magnesium in your soil exceeds 100 ppm, use either calcitic or dolomitic limestone.

Limestone Quality

Two main factors affect the ability of limestone to reduce soil acidity:

- Its *neutralizing value*
  This is the amount of acid a given quantity of limestone neutralizes when it totally dissolves. We express neutralizing value as a percentage of the neutralizing value of pure calcium carbonate. A limestone that neutralizes 90% as much acid as pure calcium carbonate has a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the less you need apply.

- Its *particle size*
  The more finely ground the limestone, the greater its acid neutralizing ability. This value is expressed as the limestone's *fineness rating*. Limestone rock has much less surface area than finely powdered limestone. It neutralizes soil acidity much more slowly.

Agricultural Index

OMAF uses the *agricultural index* to compare the acid neutralizing effectiveness of different limestone samples. Lime with a high agricultural index rating is worth more than lime with a lower rating because you apply less of it to achieve the same result. For example:

If two ground limestones, A and B, have agricultural indices of 50 and 80 respectively, the application rate of A is 80/50 times the application rate required for B. Limestone A spread on your farm is worth 50/80 times the price of limestone B per tonne.

OMAF soil test recommendations assume an agricultural index of 75. If you know the limestone's agricultural index, you can calculate the correct application rate for limestone of that quality.

Calculating Limestone Application Rates

$$\text{Application rate} = \frac{75}{\text{Agricultural Index}} \times \text{(application rate from soil test)}$$

Raising Soil pH

Use lime to raise pH when it is indicated by soil testing. General lime application rates for most crops, based on soil pH and buffer pH, appear in the table below.

Use Table 2–3 to determine how much lime you need to obtain the correct soil pH value for your crops.

TABLE 2–3. Lime Requirements to Correct Soil Acidity Using Buffer pH

Limestone needed (tonnes/hectare) based on an *agricultural index* of 75

	Target Soil pH = 6.5	Target Soil pH = 6.0
Buffer pH	**Lime if soil pH falls below 6.1**	**Lime if soil pH falls below 5.6**
7.0	2	0
6.5	3	2
6.0	9	6
5.5	17	12
5.0	20	20

Tillage Depth

These lime recommendations should increase soil pH to the target value in the top 15 cm of the soil. If you plow to a greater or lesser depth, you will need proportionately more or less lime to reach a given target pH.

Lowering Soil pH

Sulphur is the first choice for lowering pH provided the starting soil pH value is 7 or less. Other acidifying materials (e.g., aluminum sulfate, iron sulfate) are less effective than sulphur and potentially toxic to plants.

- Lowering the pH of alkaline soils (pH > 7) is not practical. In this situation, replace the soil in small areas of a field. In large fields, consider growing crops that do not require acid soil.

- Cost considerations make it impractical to acidify large fields. You can lower the soil pH in small areas by replacing the soil or amending it with large quantities of acid peat or another acidic organic material. Be sure to test the pH of any organic amendment before using it — leaf mould, compost and peat may prove to be alkaline rather than the acidic material you want.

- You must apply sulphur *at least* every other year to keep the soil pH near the desired level. Test the soil pH in the spring. If necessary, apply sulphur at the recommended rate.

Table 2–4 shows the amount of sulphur that will bring your soil to the correct pH value for your crops.

TABLE 2–4. Soil Acidification to pH 5.0 Using Sulphur

	Soil Type	
Initial pH	**Sand**	**Loam**
7.0	7.4	22.6
6.5	6.0	17.5
6.0	4.0	12.0
5.5	2.0	6.0

Kg elemental sulphur/100 m^2 for two successive years

Soluble Salts in Soil

High soil concentrations of water soluble salts interfere with plant water uptake. This can delay or prevent seed germination, kill newly transplanted plants and seriously retard the growth of either new or established plants. Levels of soluble salts can be tested by measuring the electrical conductivity (E.C.). The E.C. measurement is expressed in units of milliSiemens/cm. See Table 2–5, *Soil Electrical Conductivity Readings*, page 20, to compare known ratings with your test results.

- Ontario soils are naturally low in soluble salts. These salts rarely cause a crop production problem and are not routinely measured in soil tests. However, excessive fertilizer application, road salt runoff and chemical spills can cause soluble salts to build up in your soil. This problem is most severe when soil moisture is low and salt concentration high.

- If you suspect salt problems in your soil, send a sample to an OMAF-accredited laboratory for analysis. You must specifically request a soil E.C.

reading. See *How to Sample Field Soil,* page 15, for soil sampling instructions.

- OMAF-accredited soil testing laboratories test for soluble salts by measuring the electrical conductivity (E.C.) of a soil/water slurry. The higher the concentration of soluble salts, the greater the soil's conductivity. If testing indicates a salt problem, correct it by leaching the soil with water.

Table 2–5 interprets soil conductivity readings in Ontario field soils using a 2:1 water:soil paste mixture.

TABLE 2–5. Soil Electrical Conductivity (E.C.) Readings

E.C. Reading (milliSiemens/ cm)	Rating	Plant Response
0–0.25	Low	Suitable for most plants when using recommended amounts of fertilizer
0.26–0.45	Medium	Suitable for most plants when using recommended amounts of fertilizer
0.46–0.70	High	May reduce emergence and cause slight–severe damage to salt sensitive plants
0.71–1.00	Excessive	May prevent emergence and cause slight–severe damage to most plants
1.00	Excessive	Expected to severely damage most plants

Organic Amendments to Soil

Organic matter helps maintain soil structure, aeration and water penetration. Soil structure and aeration promote root development and plant growth while rapid water penetration minimizes erosion. When organic matter breaks down and/or is lost through clean cultivation practices, replace it by adding organic amendments to the soil.

Applying Manure

Manure supplies organic matter and many of the nutrients needed for crop production. It is most effective when applied to crops requiring nitrogen on soils that need phosphorus and potassium.

- Store manure in a way that saves the liquid portion and minimizes exposure to air.

- Do not spread manure in winter or early spring on fields subject to runoff

- For best results, apply manure in the spring. Cover it with soil the same day to prevent nitrogen loss — your crop loses about 25% of the applied nitrogen if you do not cover the manure immediately. Most nitrogen loss to the air occurs in the week after application.

- Many fields require supplemental nitrogen beyond what manure provides. When you apply manure in the fall or winter, you lose considerable nitrogen through leaching. OMAF nitrogen adjustment tables assume you will apply manure in the spring.

- The nutrient content of manure varies with a variety of factors such as livestock type, age and rations. Storage methods and water added also affect manure's nutrient composition.

How to Sample Manure

It is important to sample manure correctly.

- For liquid manure, mix the tank contents thoroughly before taking a sample.

- For solid manure, take forkfuls from many places in the stack — not just from the surface. Mix these samples thoroughly. Then submit 1–2 kg for laboratory testing.

Fertilizing

Fertilizing Field Nursery Stock

You must fertilize nursery stock regularly to achieve optimum growth and maximum profit. Dry and liquid fertilizers produce similar results, so choose a suitable fertilizer formulation on the basis of soil test results, consistent supply, handling equipment available, application cost and cost per kilogram of elemental nitrogen.

OMAF provides reliable soil test results for phosphorus and potassium. However, field soil nitrogen levels fluctuate rapidly, making nitrogen soil tests unreliable.

Table 2–6 below offers guidance on manure application rates and resulting fertilizer reductions. However, each batch of manure is unique and you must analyze it for accurate nutrient information.

TABLE 2–6. Manure Application Rate and Nutrient Adjustment Guidelines

	Nitrogen (kg/ha)			*Phosphate*	*Potash*
Class of Livestock	**Fall/Winter**	**Spring**[1]	**Spring C**[1]	**P_2O_5 (kg/ha)**	**K_2O (kg/ha)**
Liquid manure at 10 cubic metres/hectare (900 gallons/acre)					
Cattle & mixed livestock	5	10	12	4	16
Poultry	23	46	58	22	26
Swine	8	15	19	7	14
Solid manure at 10 tonnes/hectare (4.5 tons/acre)[2]					
Cattle, mixed livestock	12	24	30	10	44
Poultry	70	140	175	75	96
Swine	15	30	38	20	26

[1] *Spring* is spring applied manure not covered immediately; spring C is spring applied manure covered within 1 day or injected.

[2] Density of manure in spreader may vary from 400 kg/m³ (25 lb/ft³) for heavily bedded or very dry manure to 1000 kg/m³ (62 lb/ft³) for semi-solid and liquid manures.

Use Table 2–7 below as a guide to the phosphorus requirements of new and established plantings in your soil.

TABLE 2–7. Phosphorus Requirements for New and Established Field Nursery Stock

Phosphorus (0.5 N Sodium bicarbonate)

	Phosphate (P_2O_5) Required (kg/ha)		
Soil Test Value (ppm)	**Rating**	**New Planting**	**Established Planting**
0–3	Low	140	100
4–5	Low	130	90
6–7	Low	120	80
8–9	Low	110	70
10–12	Low	100	70
13–15	Low	90	60
16–20	Medium	70	50
21–25	Medium	60	40
26–30	Medium	50	30
31–40	Medium	40	20
41–50	High	0	0
51–60	Very High	0	0
61–80	Excessive	0	0
80+	Excessive	0	0

Use Table 2–8 below as a guide to the potassium requirements of new and established plantings in your soil.

TABLE 2–8. Potassium Requirements for New and Established Field Nursery Stock

Potassium (1 N Ammonium nitrate)

	Potash (K_2O) Required (kg/ha)	
Soil Test Value (ppm)	**Rating**	**New or Established Planting**
0–15	Low	130
16–30	Low	120
31–45	Low	110
46–60	Low	100
61–80	Low	90
81–100	Low	80
101–120	Medium	70
121–150	Medium	60
151–180	Medium	40
181–210	High	0
211–250	Very High	0
250+	Excessive	0

Fertilizing Seed Beds and Transplant Liner Beds

- Prior to planting in the spring, incorporate about 50 kg of actual nitrogen per hectare. You may wish to apply additional nitrogen during trials of particular species under specific growing conditions.

- Add organic matter, such as rotted barnyard manure or compost, prior to planting. Apply it at a rate of about 45 t/ha. Growing green manures on the land provides another good source of organic matter. Adjust rates of nitrogen fertilizers if manure is applied. See Table 2–6.

- When you add fresh, undecomposed organic matter that is low in nitrogen, you must incorporate nitrogen to compensate for microbial decomposition. For example, use 15 kg of actual nitrogen per tonne of fresh sawdust.

- When preparing the seed and liner beds, incorporate phosphorus and potassium as indicated by a soil test.

- In early spring of the second season, apply phosphorus and potassium as indicated by a soil test and apply nitrogen at the rate of 50–75 kg/ha.

Fertilizing Established Field Stock

Fertilize established field stock based on phosphorus and potassium soil test recommendations. Field soil nitrogen levels fluctuate rapidly, making nitrogen tests unreliable.

- Apply fertilizer in the spring, 2–3 weeks before growth resumes.

- Do not apply *high* rates of nitrogen after mid-July to avoid stimulating succulent growth in the fall. You may choose to apply small amounts of nitrogen regularly throughout the growing season or via a slow-release formulation.

- Fall fertilization is crucial. Research shows that growth the season after fall fertilization significantly exceeds growth after fertilization during the spring of the same season.
  - Apply up to half the year's fertilizer requirement after top growth ceases and the danger of growth stimulation (into the fall) has passed (mid-September to mid-October). Roots will grow and absorb nutrients whenever soil temperatures remain above 5°C.

- Nitrogen is either used quickly or lost through leaching. Apply nitrogen (e.g. ammonium nitrate) every season using 100–150 kg of actual nitrogen per hectare. You may apply additional nitrogen during trials of particular species under specific growing conditions.

- For optimum fertility, sandy soils need more nitrogen and potassium fertilizers than clay soils. When no soil test is available, apply 100 kg of actual nitrogen per hectare using a 3-1-2 ratio fertilizer.

- Do not apply fertilizer in late fall or winter. It will not be absorbed because of the cold soil temperatures and may be lost through runoff.

Use Table 2–9 to identify the % N of common fertilizer formulations.

TABLE 2–9. Nitrogen Sources

Nitrogen Materials	% Nitrogen (N)	Other Elements Supplied
Ammonium nitrate	33–34	
Urea	45–46	
Ammonium sulfate	20	24% Sulphur (S)
Calcium nitrate	17	37% Calcium (Ca)
Potassium nitrate	13	44% Potassium (K)

Use Table 2–10 to identify common sources of phosphorus.

TABLE 2–10. Phosphorus Sources

Phosphorus Materials	P_2O_5%
Superphosphate	20
Triple superphosphate	44–46
Monoammonium phosphate (11-52-0)	48–52 (11% N)
Diammonium phosphate (18-46-0)	46 (18% N)

Use Table 2–11 to identify common sources of potassium.

TABLE 2–11. Potassium Sources

Potassium Sources	K_2O%
Potassium chloride (muriate)	60–62
Potassium sulfate	50
Sulfate of potash magnesia	22 (11% Mg)
Potassium nitrate	44 (13–14% N)

Fertilizer Application Rates

Use this method to determine the nitrogen application rate of any nitrogen fertilizer formulation: *multiply the result by 100 to specify kg of fertilizer/hectare.*

$$\text{Kg fertilizer per } 100\text{ m}^2 = \frac{100}{\%\text{ N in fertilizer}} \times (0.5\text{ kg N}/100\text{ m}^2)$$

Nursery Container Culture

Using Pots

All current potting machines accept plastic and fibre pots.

- Use high-density plastic pots for long-term container growing.
- Fibre pots are useful for short-term growing and for winter storage or spring shipping. Fibre pots are not recommended for long-term growing because they soften, decompose and may be damaged by rough handling.
- Pot colour affects mix temperature and root development. Root growth decreases when media temperatures approach 30°C. Studies show that black and dark-green pots may be 10°C hotter than white or light reflective pots. The temperature of dark pots may reach almost 40°C on the inner surface of the sunny side. However, pots with a white or reflective exterior are not widely available. Light-coloured pots along the outside rows of a block and for widely spaced plants are recommended. Dark colours in the centre of a pot-to-pot block are acceptable, as sunlight will not strike the pot wall. To diagnose high-temperature injury, remove the pot and compare root growth on the sunny and shaded sides of the pot.
- Root circling in circular pots rarely causes problems for typical container-grown landscaping stock in Ontario. If necessary, you can minimize root circling and encourage root branching by using square pots or pots with vertical ribs. Unfortunately, large pots of these types are difficult to find.

You can usually reduce root circling in circular pots by repotting stock before the root system becomes pot bound.

Use Table 2–12 to determine how much fertilizer will supply a given quantity of elemental nitrogen per specified area when you know the percentage of nitrogen in the fertilizer formulation.

TABLE 2–12. Nitrogen Equivalency Table

	Kilograms of Fertilizer Needed to Supply:		
Nitrogen% in the fertilizer	**0.5 kg of actual nitrogen/ 100 m^2**	**50 kg of actual nitrogen/ha**	**100 kg of actual nitrogen/ha**
5	10	1000	2000
6	8.33	833	1667
7	7.14	714	1429
8	6.25	625	1250
9	5.55	556	1111
10	5.00	500	1000
11	4.55	455	909
12	4.16	417	833
13	3.84	385	769
14	3.57	357	714
15	3.33	333	667
16	3.12	313	625
17	2.94	294	588
18	2.77	278	556
19	2.63	263	526
20	2.50	250	500
21	2.38	238	476
22	2.27	227	455
23	2.17	217	435
24	2.08	208	417
25	2.00	200	400
26	1.92	192	385
27	1.85	185	370
28	1.79	179	357
29	1.72	172	345
30	1.67	167	333
31	1.61	161	323
32	1.56	156	313
33	1.50	152	303
34	1.47	147	294
35	1.43	143	286
46	1.09	109	217

Using Potting Mixes

A successful container-growing operation depends on the potting mix.

- Before using a potting mix, ensure it is well composted. Stockpile it for several months and turn it occasionally.
- The mix ingredients need to be free of insects, diseases and weeds, readily available (to assure a continuous supply) and reasonably priced.
- Where possible, use a potting mix that is heavy enough to support plants in the wind. Staking the outside rows of container crops helps reduce blow-over of tall plants.
- The traditional mix has been peat combined in equal measure with concrete-grade sand. However, this mix becomes alkaline when the sand has a high pH and aeration is somewhat low.
- Composted bark provides good aeration when mixed with peat. Mixes such as 2 parts bark to 1 part peat *or* equal parts bark and peat to 1 part sand provide adequate aeration and water holding capacity. Composted bark may also help to suppress root disease organisms in the root zone.
- Well-decomposed coarse sawdust is a useful mix ingredient. Avoid fresh sawdust due to its very high carbon/nitrogen (C/N) ratio. Generally, the lower the C/N ratio, the faster the material will decompose. The C/N ratio of sawdust is 1,000/1, of conifer bark 300/1 and of hardwood bark 150/1. Therefore, hardwood bark will decompose more quickly than conifer bark. To compensate for a high C/N ratio and enhance decomposition, add 1 kg of actual nitrogen (e.g. ammonium nitrate) per cubic metre of bark.
- Adequate aeration is vital. Since roots require oxygen to grow properly, a poorly aerated mix will restrict root growth. Water holding ability is also important, though secondary to aeration.

Using Soilless Media

Soilless media differ greatly (chemically and physically) from field soils.

- Much of the soilless container mixes used in Ontario are comprised of composted bark (50%–65%), sphagnum peat (30%–40%) and other composted waste (up to 10%). Inorganic compounds such as perlite or vermiculite may also be added to improve aeration.
- Peat and bark-based media have good aeration and moisture-holding properties but limited nutrient-holding capacity. You must manage fertility closely to achieve maximum crop growth potential.
- High pH affects the availability of most micronutrients. Therefore, avoid growing media with pH > 6.5. High pH values from the addition of coarse sand may lead to low levels of iron or manganese.

Determining Potting Mix Porosity

Use this method to test new potting mixes. Compare plants grown in your standard potting mix with plants grown in a new one to select the best media.

- The *total porosity* of a mix is the space between mix particles that air or water can potentially fill. Aim for a total porosity value above 50%.
- The *aeration porosity* of a mix is the per cent of space filled by air after irrigation water has drained out. To determine this vital value, follow the steps outlined below. Aeration porosity should be >15% and <30%. Too much aeration (aeration porosity >30%) will not harm the plants, but will require frequent irrigation. A potting mix with a high percentage of very fine particles (i.e. <0.5 mm) results in low aeration porosity and poor drainage.

Use mixes with a high aeration porosity, 20%–25%, for pines and yews. Junipers and white cedar can tolerate lower aeration porosity values.

To determine media porosity, you will need:

- your normal growing pot (#1, #2, etc.)
- a way to cover or plug the pot drain holes
- a graduated cylinder or other liquid measure
- some dry potting mix

To calculate the porosity of your potting mix:

1. Cover or plug the drain holes of the container.

2. Fill the container with water to the normal level of the potting media. Measure the volume of this water and record the number. This amount of water is the *total container volume* [A].

3. With the pot empty and the drain holes still plugged, fill the container to the normal level of the potting media with slightly moist media. Be sure that the container is level.

4. Slowly add a known volume of water to the media. Continue adding water until a water slick appears on the surface. The volume of water added is the *pore volume* of the media [B]. Record the amount of water you added.

5. Without moving the pot, remove the drain hole covers or plugs. Let the water drain into a bucket, then measure the volume of water that drained. This is the *aeration pore volume* [C]. Record this number.

6. Calculate the media porosity:

Total porosity = $\frac{(B \times 100)}{A}$

Aeration porosity = $\frac{(C \times 100)}{A}$

Water retention porosity = total porosity – aeration porosity

For example, **if:**

Total container volume **[A] = 5180 mL**

Pore volume (water added to saturate the media) **[B] = 3354 mL**

Aeration pore volume (water drained from container) **[C] = 1080 mL**

then:

Total porosity = $\frac{(3354) \times (100)}{5180}$ = **65%**

Aeration porosity = $\frac{(1080) \times (100)}{5180}$ = **21%**

Water retention porosity = 65% – 21% = **44%**

Adjusting Potting Mix pH

It is important to maintain the right pH for your container crops.

- Maintain a potting mix pH between 5.5 and 7.0.
- Do not use alkaline sand in the mix when growing pH sensitive crops.
- Acidifying fertilizers may help to control pH. When using injectors, apply fertilizer and acid concentrates as separate solutions.
- You can acidify irrigation water with nitric or phosphoric acid, depending on the bicarbonate content of the water.
- *Juniperus* and *Thuja* will grow adequately at a higher pH, but plants such as *Euonymus*, *Rhododendron* and *Taxus* will exhibit iron and/or manganese chlorosis if the pH is above 7.0.

Fertilizing Container Stock

Most container mixes contain little or no soil, with resulting low fertility. You may apply water soluble or controlled-release fertilizers to correct this problem.

Fertilizers affect the environment, especially the ground water. Liquid feeding with water soluble fertilizers was widely accepted in the past. However, given current environmental concerns, it is important to strive for maximum efficiency and minimum environmental impact from your fertilizer program. You can do this by minimizing container leaching plus collecting irrigation and leachate water runoff.

How to Sample and Test Container Soils

It is important to sample your soil correctly.

- Potting mixes do not retain nutrients due to rapid leaching. This makes soil tests a vital part of container production operations. Sample every 2 weeks. As test results become familiar, pH and soluble salt (E.C.) readings may provide sufficient biweekly information, along with an occasional nutrient analysis.
- To obtain a sample, remove the pot and take a core through the medium midway between top and bottom.

- Sample container-grown stock with a small-diameter sampling probe.
- Take samples from at least 10 pots.
- If you apply water soluble fertilizer continuously, sample the soil a half hour after application.
- When using a dry surface fertilizer (granular or pellet), always sample before adding the fertilizer. Insert the probe carefully, avoiding any surface fertilizer residue.
- When both are applied at recommended rates, water soluble fertilizers normally produce lower salt concentrations than preincorporated controlled-release fertilizers.
- Analyze all soil samples from container potting mixes at an OMAF-accredited laboratory using a *saturated paste analysis for greenhouse media.*
- Garden centres must continue controlling the fertility of container-grown plants to ensure proper growth — especially with plants grown previously using liquid fertilizers. Add a controlled-release fertilizer according to the manufacturer's recommendation. Do not add fertilizer on the surface before shipping.

Using Water Soluble Fertilizers

Apply water soluble fertilizers through the irrigation system using an accurate concentrate diluter. Under conventional overhead irrigation, water soluble fertilizers leach quickly from container media. Because collection of runoff water is not standard practise, the fertilizer salts can move to underlying soils and groundwater systems. To reduce the amount of leached salts, reduce fertilizer rates and reduce the amount of water passing through the media (e.g. pulse or cyclic irrigation).

- In theory, soluble fertilizers are applied at every watering. However, this does not use water and fertilizer efficiently. Actual results indicate little difference in growth from constant vs. intermittent fertilizing.
- When water soluble fertilizers do not contain micronutrients, add these to the mix before potting or as soluble trace elements during the growing season. Dry materials with added bulking agents are less concentrated, making them easier to blend into the mix. Use these as recommended by the manufacturer.
- Commercial water-soluble fertilizers come in numerous analyses (e.g. 20-20-20 or 28-14-14). Use them at the rate of up to 200 ppm nitrogen (i.e. up to 100 g of 20-20-20 per 100 litres of water) for constant feeding.

**Calculating Parts/Million (ppm)
of a Dilute Liquid Feed**

$$\text{ppm nutrient} = \frac{(\text{fertilizer weight in g}) \times (\%\text{ nutrient in fertilizer}) \times (10)}{(\text{volume of stock solution in L}) \times (\text{injector dilution rate})}$$

**Calculating Fertilizer Needed
to Obtain a Given Nutrient Level
in Dilute Feed**

$$\text{g fertilizer per litre} = \frac{(\text{ppm diluted feed}) \times (\text{injector dilution rate})}{(\%\text{ nutrient in fertilizer}) \times (10)}$$

Using Controlled-Release Fertilizers

Controlled-release (encapsulated) fertilizers work well with container stock.

- You can incorporate controlled-release fertilizers into the potting mix or top dress with them later. Use as suggested by the manufacturer.
- Avoid excessive mixing when preparing a potting mix. This may break fertilizer particles, which can cause problems due to excessive salt.
- Do not store potting mixes with preincorporated, controlled-release fertilizers for an extended time period.
- Several controlled-release fertilizer formulations now contain micronutrients. When controlled-release fertilizers do not contain micronutrients, add these according to the manufacturer's recommendation.
- Research suggests that supplemental fertility, particularly nitrogen, may benefit fast growing crops when using controlled-release fertilizers. Nitrogen soil tests *are* reliable for container soil. Apply

nitrogen (e.g. ammonium nitrate) to the plants at the rate of 200 ppm whenever soil tests show unacceptably low nitrogen values (i.e. under 39 ppm).

- Check soil test values in early July of the second growing season after using preincorporated controlled-release materials. You may supply necessary nutrients via water soluble fertilizers in the irrigation system or through surface fertilizer applications. Some controlled-release materials provide nutrition for two growing seasons.
- Controlled-release fertilizers may produce inconsistent soil test results if capsules break during sampling, shipping or testing.
- Research shows that *Juniperus* grows better the first year when you preincorporate fertilizer in mixes with low aeration porosity. When a small plant is growing in a 6 L pot, watering to fertilize may cause poor growth due to low aeration.

Measuring Nutrient Levels of Container-Grown Crops

It is important to sample your media correctly. See *How to Sample and Test Container Soils*, page 25, for sampling instructions.

- Woody plants use both nitrate and ammonium types of nitrogen. Under most summer conditions, ammonium nitrogen converts quickly to nitrate nitrogen due to micro-organism activity.
- Current container soil tests measure nitrate nitrogen. However, ammonium nitrogen can be measured on request.
- Controlled-release fertilizers may produce inconsistent soil test results if capsules break during sampling, shipping or testing.
- OMAF-accredited laboratories report container media nutrients in parts per million (ppm).

Fertilizer Application Rates

For landscape plantings, apply nitrogen at 1.5–2.0 kg actual N per 100 m^2. Water thoroughly after application. Low tree vigour, a long growing season and/or well drained sandy soil may necessitate higher application rates. [See Table 2–13, *Nutrient Levels for Most Container Crops*, page 28.]

Fertilizing Landscape Plantings

Most soils have enough inherent fertility to grow plants — there is no need to fertilize thriving landscape plants. Fertilize based on a soil test, soil characteristics, type of plant and desired growth.

- Fertilizer helps plants establish after transplanting and improves plant vigour.
- Trees growing in lawn areas benefit from fertilizers applied to the grass — apply herbicide-free turf fertilizer at a rate slightly above the recommended rate for grass.
- Any complete, high nitrogen fertilizer is fine for trees and shrubs. Most studies show that nitrogen improves plant growth more than phosphorus and potassium. Distribute the required amount of fertilizer evenly on the soil surface beginning well beyond (as much as 2 times beyond) the dripline. Extend the fertilizer inward to 2/3rd the distance between the dripline and the trunk. If paving obstructs part of the area under the branch spread, reduce the quantity of fertilizer accordingly.
- You may split fertilizer applications during the year, applying up to half the annual rate in the fall. Apply fertilizer in the early spring, 2–3 weeks before growth begins. Fertilize again in the fall after top growth ceases and the danger of growth stimulation has passed (mid-September to mid-October).
- To avoid stimulating top growth into the fall, do not use large amounts of fertilizer with readily available nitrogen between mid-July and early September
- If you will fertilize only once, use fertilizers with 60% or more of their nitrogen in slow release form, since the nutrients become available slowly with minimum leaching. Pressure injecting slow release fertilizer into the soil is acceptable.
- If the soil needs aeration or when it is important not to overstimulate the vegetation growing on the surface, use the drill hole method of tree fertilization.

TABLE 2–13. Nutrient Levels for Most Container Crops

Nutrient Concentration		**What to Do**
Nitrogen (as water-soluble nitrate nitrogen NO_3 N)		
Low	0–39 ppm	Add extra nitrogen to the feeding program, especially if using slow-release materials.
Normal	100–199 ppm	Continue feeding at high levels and check total salts.
Excess	250+ ppm with high salts	Discontinue feeding nitrogen and check total salts as root damage may occur. Higher rates may be needed for optimum growth in a bark mix and to maintain the same soil test level as in a peat mix.
Phosphorus (as water-soluble P)		
Low	0–2 ppm	Add additional phosphorus to the feeding program.
Normal	6–9 ppm	Continue feeding at high levels and check total salts.
Excess	50+ ppm	Discontinue feeding phosphorus.
Potassium (as water-soluble K)		
Low	0–59 ppm	Add additional potassium to the feeding program.
Normal	150–250 ppm	Continue feeding at high levels and check total salts.
Excess	350+ ppm	Discontinue feeding and leach. Plants may tolerate higher levels if the mix contains a high proportion of organic material. (Leaching is ineffective for removing incorporated controlled-release fertilizer.)
Soluble Salts (E.C.) in mS/cm (mhos x 10^{-3}/cm)		
Low	0–0.75	Check for adequate nitrogen and potassium levels.
Normal	2.0–3.5	Continue the feeding program.
Excess	3.5+	Discontinue feeding. Plants may tolerate higher levels if the mix contains a high proportion of organic material.
Calcium (as water-soluble Ca)		
Low	0–79 ppm	Add extra soluble calcium to the feeding program. (Calcium levels are easily raised by adding dolomitic lime or gypsum to the media.)
Normal	200–300 ppm	
Excess	400+ ppm	
Magnesium (as water-soluble Mg)		
Low	0–29 ppm	Apply 0.5 kg/1,000 L of magnesium sulfate through the irrigation water.
Normal	70–200 ppm	
Excess	200+ ppm	
Miscellaneous		
	Sulfate levels should not exceed 300 ppm	
	Chloride levels should not exceed 50 ppm	
	pH should fall between 5.0 and 6.5	

Irrigation Water Quality

Irrigation water quality is one of the most important parts of a growing system; yet it is often overlooked. Irrigation water has a significant influence on the characteristics of the media in container production. Over successive irrigation cycles, the chemicals present in the water affect the pH, soluble salts, bicarbonate level and other chemical properties of the media. Media in smaller pots are affected more quickly than larger pots, due to the reduced buffering capacity of the smaller media volume. The effects on media will, in turn, affect plant growth. Common symptoms of water quality problems may include: nutrient deficiency symptoms (e.g. improper pH), interveinal and leaf margin browning (e.g. accumulation of salts) and poor root growth.

Along with media and leachate analysis, test irrigation water throughout the growing season. Water quality is at its highest in spring when water volumes are at their highest. Soluble solutes are more dilute in spring, giving lower E.C. values. Bicarbonate levels are also lower in spring. For these reasons, test irrigation water quality in the spring and compare it with subsequent summer and early fall water tests. There are a number of chemical attributes to be tested when sending a water sample in for analysis. See Table 2–14, *Acceptable Ranges for Chemical Properties of Irrigation Water.*

- Collect samples of irrigation water below the water surface, around the level where the intake line sits. Try to collect water samples when the bottom sediment hasn't recently been disturbed. Collect approximately 500 mL (about the size of a bottle of spring water) and refrigerate until submission to the lab.

- When lab results indicate certain chemical properties appear beyond the acceptable range, your options are:
  - find an alternate source of irrigation water where chemical properties fall within the acceptable ranges
  - find an alternate source of irrigation water for those plants that are most sensitive or have the smallest pot volume
  - leach excess solutes from container media through supplemental irrigation with the same water source
  - water treatment to remove salts (e.g. reverse osmosis) is a an effective but costly solution.

- Most southern Ontario soil has a limestone base, which gives soils and groundwater their alkalinity. Although pH is a good indication of the acidity or alkalinity, the level of bicarbonate is a better indication of the true alkalinity. The higher the level of bicarbonates, the more difficult it will be to lower the pH to an acceptable level. Water pH problems can be corrected with the injection of nitric or phosphoric acid, depending on the bicarbonate content of the water.

TABLE 2–14. Acceptable Ranges for Chemical Properties of Irrigation Water*

Chemical Property	Acceptable Range for Most Container Woody Crops	Acceptable Range for Most Herbaceous Perennials/ Greenhouse Crops
pH	5.0–7.0	5.0–7.0
EC (soluble salts)	< 1.75 mmho/cm	< 1.0 mS/cm
Calcium Carbonates ($CaCO_3$)	< 150 ppm	< 120 ppm
Bicarbonates (HCO_3)	< 150–200 ppm	< 150–200 ppm
Sodium (Na)	< 70 ppm	< 60 ppm
Chloride (Cl)	< 140 ppm	< 100 ppm
Sulphur (S)	< 30 ppm	< 30 ppm
Sulphates (SO_4)	< 200 ppm	< 200 ppm
Boron (B)	< 0.8 ppm	< 0.5 ppm

* These ranges are a general guideline, ornamentals vary greatly in their sensitivity to soluble salts and water chemical properties.

3. Insect and Disease Management

Insects, mites, fungi, bacteria, nematodes and viruses are all examples of pests found on plants. In nature, most pests populations are kept "in check" by other predators, natural pathogens, competing organisms or by the natural resistance of a healthy host plant. When other factors, such as stress, enter the system pests may become economically damaging.

In production systems, pests have increased opportunities to become damaging. Crops are produced in a monoculture system, allowing easier host-host transmission of pests. As well, some production practices allowing mass production can be quite stressful. For example, container-grown plants have high root zone temperatures in the summer, which decreases plant health and reduces resistance to pest invasion. Successful growers look for early signs of plant stress to help prevent pest problems.

Integrated Pest Management

Integrated Pest Management (IPM) is a decision-making process that integrates all available tools to reduce pest populations to an acceptable level in a cost-effective, environmentally rational manner. These tools include monitoring, cultural control, physical control, biological control and chemical control. Nursery and landscape professionals are adopting a more integrated approach to pest management which allows them to decrease their use of chemical pesticides by making more informed decisions.

Monitoring

Monitoring is the most important aspect of IPM. Monitoring data provides the basis for making informed decisions about pest management practises. Monitoring programs consist of weekly physical examinations of all production areas during the growing season, including winter propagation. Monitoring can be carried out less frequently on plants in the dormant state.

When making decisions about pest management, the grower or landscape professional needs to determine the level of a pest population that can be tolerated. These levels (called **action thresholds**) depend on many factors. Because the diversity of ornamental plants and plant pests is so great, data for specific pest action thresholds is often unavailable. By keeping good records, growers and landscape maintenance professionals can develop their own action thresholds. Action thresholds may be measured by the number of pests present, the percentage of plant parts showing symptoms or the point of pest injury before the economic loss from that injury is equal to the cost of control (known as **Economic Injury Level**). Most healthy ornamental plants can tolerate moderate levels of damage, but landscape clients and retail garden centre customers may have lower tolerances.

Early detection is the key to preventing pests from reaching levels of economic injury and minimizing the use of chemical pesticides.

Crop Scouts

Crop scouts should be dedicated to the monitoring and reporting of crop health observations as their reports direct the pest management program. Crop scouts should:

- sample plants from each production block and look closely under branches, in branch crotches and leaf undersides for any unusual symptoms
- examine the crown and root systems regularly to monitor for diseases and insect infestations.

A good crop scout needs a basic understanding of crop health, including some background in plant pathology, entomology and weed science. Given the wide array of woody and herbaceous ornamentals grown in Ontario, clearly labelled blocks of plants (including cultivar names) should be available for the scout's reference. In the case of landscape properties, a basic map with plant names is an excellent reference for monitoring. Correct identification of the host is often critical for the correct identification of the pest.

With a wide array of crop species comes an extensive group of organisms (insects, mites and micro-organisms) that may be encountered during crop production. Not all these organisms are plant pests; many are incidentals that happen to be there or are feeding on other non-plant organisms. To aid in pest identification, make sure the crop scout has access to diagnostic references that outline identifiable characteristics, host lists, biology and life cycle of the plant pests typically encountered. This information can then be used to identify the pest and target where in its life cycle to use various control methods. A hand lens (e.g. 10×–20×) is a necessary tool for observing a pest's diagnostic features. Diagnostic references may include ornamental woody and herbaceous reference books, government and university publications and internet sites. For more information on diagnostic references, see the OMAF Nursery-Landscape Web page at www.gov.on.ca/OMAF. The Pest Diagnostic Clinic offers pest identification services. [see *Appendix E*]

GDD and Phenology Models

In the past, calendar dates were used to determine when to apply pesticides. This often lead to unnecessary pesticide applications and ones that did not coincide with the susceptible developmental stage of the pest. Today, new pest management techniques include temperature, weather data and plant-pest phenology (developmental) models. The underlying principle is basic: plants and insects need a certain amount of heat to pass through the various stages of development. The temperature data is often expressed as Growing Degree Days (GDD). To calculate: collect maximum and minimum temperatures over a 24-hour period. Then use the following formula and the collected data to calculate GDDs with various base temperatures (i.e. 10°C, 50°F):

Equation

$$\frac{(\text{Daily Max Temp + Daily Min Temp})}{2} - \text{Base Temperature} = \text{\# GDD's}$$

Daily Max Temp = daily maximum air temperature
Daily Min Temp = daily minimum air temperature
Base Temperature = it is developed experimentally and is specific to the organism being monitored. It reflects the minimum base temperature or threshold below which organism development does not occur.

Example: $(17°C + 5°C)/2 - 10°C = 1$ GDD (at base = 10°C)

Growers and landscape professionals use GDD models to help predict the emergence of pests based on temperature data they have collect or from the local weather office. The GDD pest models can be used to fine-tune the monitoring program and catch pests early. Over time, recorded temperature data for plants and plant pests reveal that certain plants and insects pass through developmental stages at the same time. For example, when the *Magnolia x soulagiana* flowers are in the pink bud stage, the overwintering spruce gall adelgid nymphs are starting to feed and are susceptible to applications of dormant oil or chemical insecticides. The fruiting and flowering characteristics of certain ornamentals ("plant phenology indicators", Table 3–3, page 41) common in the landscape have been linked to the development and susceptibilities of plant pests.

Where plant health monitoring will be carried out in many locations (as in the case of landscape maintenance), use plant phenology indicators to direct the monitoring program. The combined collection of GDD data and plant phenology indicators can give a clearer picture of pest emergence and opportunities for control. For more information, see *Phenology & Growing Degree Day Tables for Monitoring* on pages 41 to 52.

For more information on timing and control methods for ornamental pests in Ontario, check out the OMAF Nursery and Landscape Agriphone message on the OMAF Web site (www.gov.on.ca/OMAF) or call 1-888-290-4441 to listen to the telephone recording (from April to October).

Monitoring Tools

Many tools exist to help crop scouts monitor plant pests. Although they are collectively called "traps", many of these tools are not effective at controlling pest populations. Use them only as a means of identifying emergence and peak population type data.

- **Baited traps** are used primarily as pheromone (mating) lures or other lures (e.g. floral lures) to attract insects. Place at least 2 traps per monitoring area about 1 week before adults are expected to emerge. Place traps on the windward side of the monitoring area. Try to be consistent with pheromone types and brands.

- **Refuges** provide places for insects to hide (e.g., burlap traps for black vine weevil adults, gypsy moth larvae).

- **Sticky traps** (yellow, blue, etc.) catch flying insects (e.g., aphids, whiteflies, leafminer adults, thrips, leafhoppers). You must be familiar with insect identification to be successful.

- Wrap **tape** around stems and small branches (sticky side out) to capture scale insect crawlers (for monitoring purposes only).

- **Tapping trays** have a white surface held on a frame (or paper on clipboard) that is held beneath a tapped branch. They are useful for monitoring mites, plant bugs (e.g. honeylocust) and caterpillar droppings.

- **Pitfall traps** can be a cup-shaped tray placed in the ground (top of tray is level with ground surface) and can be used to monitor flightless pests (such as root weevil adults, slugs).

Monitoring Data Records

If you are monitoring your plants, record the observations in an organized and accessible system (e.g. a computer data file). Remember, this monitoring data is very useful in fine-tuning your action thresholds and pest management strategies in future years. Organize your monitoring data under the following headings:

- date (month/day/year)
- location (e.g. Farm X, block C)
- host (including cultivar or variety, stage of development)
- pest or symptoms (including pest population, pest stage of development,% plants or plant parts showing symptoms)
- GDD and/or plant phenology indicator
- action taken (e.g., pesticides, rate, area treated)

A sample *Pest Monitoring Record Sheet* can be found in Appendix H, page 139.

Indicator Plants

Indicator plants are those ornamentals that seem to attract specific pests first (i.e. leafhoppers on *Caragana* sp.). Examine these plants at the beginning of each monitoring cycle. By knowing your indicator plants, you may detect pest problems before they reach economically damaging levels. For more information, see the OMAF Web site at www.gov.on.ca/OMAF.

Cultural Control

Cultural control activities are really modified plant care practices. Remove infested plant material or pests (including weeds) from production areas and landscapes. Have them destroyed. Practice supplemental irrigation where natural precipitation events are inadequate. Avoid irrigation late in the day as extended leaf wetness periods into the night creates disease problems. Irrigate less often, but with larger volumes to encourage deeper rooting. Grow plant varieties that are tolerant of diseases and insects (e.g. *Betula nigra* varieties are more tolerant of bronze birch borer). Steam pasteurize propagation media before reusing. Select only healthy plants for cuttings and budwood to avoid introducing problems into your production system.

Physical or Mechanical Control

Physical labour, such as mechanical cultivation of field soils to injure weeds and expose soil insects to natural predators, can also reduce pest populations. Apply sticky bands on the trunks of landscape trees to exclude crawling insects and prevent egg-laying (e.g. adult females of the fall cankerworm). Using yellow sticky tape in propagation greenhouses offers supplementary control of flying insect pests. When new plant material is received by a nursery, hold it in a quarantine area (away from production areas) and monitor for any pests or diseases.

Biological Control

There are many natural predators and parasites that keep pest populations in check. Ladybird beetles (larvae and adults) and lacewings (larvae) are predators. They feed on soft-bodied insects like aphids, mites and scale nymphs. Ichneumonid wasps are parasites. The adult females lay their eggs inside soft-bodied insects like aphids. The wasp eggs hatch and feed on the contents of their aphid host, eventually killing the host. Many broad spectrum insecticides used to reduce pest populations also reduce populations of natural predators. When monitoring for pest populations, look for natural predators and parasites as they are also an important source of pest control and may function in place of an applied pesticide.

Many biological control organisms are commercially available in Ontario. Most biological control products are available for the control of insects and mites and are most successful in closed systems (i.e. greenhouses). Some predatory insects and mites can be effective in the field, especially where a continuous supply of pollen and nectar are available to them. Recent studies with entomopathogenic nematodes (*Heterohabditis megidis*, Nemasys H^{TM}, Heterhabditis System^{TM}) have shown excellent control of root weevils in container production and about a 50% reduction of root weevil populations in the field. For more information on biological control products search the Internet or contact the Agriculture Information Contact Centre at 1-877-424-1300.

Chemical Control

When all other methods of control fail or when pest populations are threatening the economic value of the plants, chemical pesticides may be the most effective solution. The pesticide program is an important part of IPM. Make your choices regarding pesticide applications in accordance with monitoring observations. Choose the most appropriate product, keeping in mind the pest and host plants it is to be used on. Apply the product to coincide with the susceptible stage of the pest (according to monitoring observations). Before using a pesticide, read the product's label and understand its relative toxicity, mode of action, persistence, proper and safe application. For more information on pesticide safety, see Chapter 1.

Chemical pest control products are an important tool in crop production but they must be used carefully to minimize their impact on the environment and prevent issues like resistance. Resistance is the evolutionary adaptation of a population to survive a pesticide dose that is lethal to most of its individuals. Pests become resistant to chemical pesticides when the products are used incorrectly or too often. Make note of the chemical family of each pesticide and ensure that chemical families are being rotated during the application period for each target pest. [See Table 3–20, *Chemical Families*, on page 58 and Table 3–21, *Insecticides and Fungicides Used to Protect Ornamentals*, on page 59.]

Best Management Practises

As a grower or landscape professional, you have a major influence on plant health through environment (media, soil, irrigation, temperature, hardiness zone, light, spacing, planting location, etc.) and nutrients (type, rate, delivery). Slight changes in environment and nutrient availability can have dramatic effects on plant health. In the landscape, a significant portion of pest problems are due to inappropriate site conditions. Before installing landscape material, consider the basic needs of the plants (hardiness zone, soil pH, light requirements, soil type, water, etc.). By following practises that produce and maintain healthy plants, you can prevent a lot of plant pests from causing economic damage.

Best Management Practices (BMP's) are the outcome of good crop management. Every grower and landscape professional has a set of guidelines they follow to produce and maintain plants in a responsible manner. Many BMP's pertain to sound water and fertilizer use (both for healthy plants and a healthy environment), the recycling of plastics and the responsible use of pesticides. By monitoring irrigation water quality and analyzing growing media/leachate, you can produce healthier plants by catching problems early.

Sample irrigation water from each water source — in the spring, summer and fall. It is good to test at least 3 times/year since water levels change throughout the seasons, influencing the concentration of harmful salts. Have the samples tested for pH, EC, bicarbonates, sodium, chloride, sulphur, sulphates and boron at an accredited lab. See Table 2–1, *OMAF Accredited Soil, Leaf and Greenhouse Media Testing Laboratories*, on page 16 for a list of accredited labs and Table 2–14, *Acceptable Ranges for Chemical Properties of Irrigation Water*, on page 29 for a comparative table for chemical properties of good quality irrigation water.

In the nursery, sample container leachate by using the Pour-Thru Procedure (or Virginia Tech Extraction Method) for nursery crops (www.ces.ncsu.edu/depts/hort/hil/hil-401.html). Allow 30–60 min. to let pots drain after irrigation. Place saucers or pots with plastic bags under the pots to be sampled. Pour enough distilled water over the pot surface to collect about 50 mL of leachate from the pot bottom. Take leachate samples from 5 pots per block (or irrigation zone) to get a good representation of the block. Sample media or leachate every 2 weeks and submit the samples to an accredited lab. Compare E.C. and pH over time and monitor fertilizer salts (N, P, K) in the soil solution. Over time, you will develop a database that correlates salt levels and pH with healthy plant growth. Spikes in salt levels will be detected early and remedial watering to leach out salts will take care of root problems before they start. Analysis of fertilizer salts will reveal peak levels of fertilizer release and periods when supplemental applications may be warranted. In the field or landscape, sample soils where new plantings are to take place or where plant growth seems to be below optimum. See Table 2–7, *Phosphorus Requirements for New and Established Field Nursery Stock* and Table 2–8, *Potassium Requirements for New and Established Field Nursery Stock*, on page 21 for directions on testing container media and field soil, and Table 2–13, *Nutrient Levels for Most Container Crops*, on page 28, for information on adequate soil nutrient levels.

Insects and Mites Affecting Trees and Shrubs

Insects and mites are broadly classified according to their feeding habits and the associated damage they cause to woody plants.

- Defoliators
- Sucking insects
- Borers
- Gall makers
- Soil pests

Some damage is so characteristic you can identify the causal insect without seeing the pest at work. A hand lens (e.g. 16×) can be helpful to see some tiny pests such as mites. Other pests develop within the plant tissues, concealed from view.

Defoliators

Defoliating insects eat solid foliage tissue. They may feed singly or in dense colonies and have diverse feeding habits. For example, some defoliators consume entire leaves while others eat only interveinal tissue; some skeletonize the leaf surface while others mine between the leaf surfaces.

Some defoliators are visible on leaves while others hide within a web, folded leaf or portable shelter. They damage plants by reducing the leaf area of the plant. This interferes with photosynthesis, depriving the plant of food. It also interferes with the transportation and translocation of food within the plant. Some common types of defoliators are listed below; a compendium of pests and diseases appears on page 62.

Caterpillars

Caterpillars are moth and butterfly larvae. They may feed in colonies or individually. Caterpillars have 3 pairs of true legs on the abdomen, close to the head. About 5 pairs of fleshy "pro-legs" are located further back along the abdomen. Loopers or "inch worms" are examples of caterpillars, they have 2–3 pairs of fleshy pro-legs.

Leaf Eating Beetles

Many beetles feed on leaves both as adults and as larvae. Beetle feeding can completely devour, skeletonize, or mine the leaves.

Leafminers and Casebearers

Leafminer and casebearer larvae develop within leaf tissues or in a protective case of leaf fragments that they carry to their feeding site. While the pests are often concealed, their characteristic tunnels make leafminer infestations easy to identify. The tunnels may be straight, serpentine or irregular.

Sawflies

Sawflies feed in colonies and quickly strip foliage from their host plants — usually during June and July. The adults have 2 pairs of wings and often resemble small, amber- coloured bees. The larvae of most species look similar to caterpillars, with 3 pairs of true legs on the abdomen (close to the head). They usually have 7–8 pairs of fleshy "pro-legs" located further back along the abdomen.

Sucking Insects

Sucking insects include aphids, lacebugs, leafhoppers, mealybugs, mites, scales, spittlebugs and thrips. This group of pests weakens trees and shrubs by sucking the sap. Some also inject secretions that injure or kill plant cells. Most species, though small and inconspicuous, are very troublesome pests.

Because their foliage is not chewed or torn, infested plants may suffer severe injury before symptoms appear. Signs of damage include mottling and fading leaf colour, curling and twisting leaves, wilting foliage and tender shoots, hardening flower buds and malformed flowers.

Some common types of sucking insects are listed below; see *A Compendium of Pests and Diseases with Recommended Management Practices* on page 62.

Aphids

Aphids (plant lice) are small, soft bodied, pear-shaped insects that vary from green to shades of red, brown or black. Some aphids feed on the leaves; others feed on the roots. Aphids commonly cluster on new growth or on the underside of leaves.

Aphids secrete a sweet sticky substance called "honeydew" which attracts ants, flies and wasps. Honeydew can be a nuisance when it coats objects beneath infested plants. A black sooty mould may grow on the honeydew, making the plants unsightly.

Leafhoppers

Leafhoppers are small, wedge-shaped, active insects that run, hop or fly when disturbed. Leafhoppers are usually greenish or yellow in colour, though some are striped. They commonly injure woody hosts such as apple, elm, honeylocust, maple and rose.

Leafhoppers feed on the undersides of leaves, causing stippling or bleaching. Small whitish dots appear on the leaves' upper surface. The light coloured, cast skins of nymphs often remain attached to the lower surface of a leaf, a critical clue to help identify the pest problem.

Mites

Mites are tiny animals related to spiders and ticks — not true insects. Sometimes called "spider mites" they produce webbing between plant needles or leaves. This keeps the mites from becoming dislodged and protects them from their natural enemies.

Mites reproduce rapidly during hot, dry weather and may produce several generations a year. They attack evergreens and deciduous trees, causing speckling, bleaching or bronzing of foliage. Tiny spherical eggs or broken eggshells appear as specks or spots. In severe mite infestations, foliage may drop prematurely.

Serious mite damage happens quickly, so it is important to identify mite infestations early in the season. Most mites are not visible with the naked eye. To identify a mite infestation, use a 16×-hand lens. Alternatively, hold a sheet of white paper under a branch and tap the branch sharply. Some mites will drop onto the paper — they appear as tiny specks as they crawl about.

Mite species commonly associated with trees are:

- **Clover mite** (*Bryobia praetiosa*) on honeysuckle and elm
- **European red mite** (*Panonychus ulmi*) on fruit trees
- **Oak red mite** (*Oligonychus bicolor*) on oaks
- **Honeylocust spider mite** (*Eotetranychus multidigituli*) on honeylocust
- **Spruce spider mite** (*Oligonychus ununguis*) on spruce, hemlock, arborvitae and juniper
- **Two-spotted spider mite** (*Tetranychus urticae*) on elm, linden, rose and ornamental fruit trees
- **Rust mites** (various) on elm, honeylocust, maple, oak and privet

Thrips

Thrips are tiny, slender-bodied insects that affect the leaves and flowers of honeylocusts, privets and pines.

Plant Bugs

This group of insects removes plant sap using piercing, sucking mouthparts. Both adults and nymphs cause damage, often injuring the young, developing shoots and leaves. Symptoms of damage include stippled leaves, deformed leaves and stunted shoots.

Scale Insects

Scale insects are tiny and inactive for most of their lives. They often blend with the host plant's colour, making them hard to find. For ease of identification, scales are divided into 3 groups:

- armoured scales
- soft or unarmoured scales
- mealybugs

Armoured scales

Armoured scales are common on trees and shrubs. The scales vary in length or diameter from 2–3 mm and secrete a hard, waxy covering over their bodies. Armoured scales may be circular, oblong or pear-shaped.

Soft scales

Soft scales are either bare or enclosed in waxy or cottony secretions.

Mealybugs

Mealybugs are soft-bodied insects that are usually covered with a powdery, cottony-wax material and produce honeydew. They range from about 5–8 mm long when full grown and, unlike other scale insects, mealybugs can move about throughout their entire life cycle.

Borers

Borers are beetle and moth larvae that tunnel into the buds, shoots, bark or wood of trees and shrubs. Some species attack healthy trees, but most attack trees and shrubs already weakened from another stress. Emerald ash borer (*Agrilus plannipenis*) and Leopard moth (*Zeuzera pyrina*) are 2 of the newest borers found in Ontario. They both feed on green ash. For more information see *A Compendium of Pests and Diseases with Recommended Management Practices* on page 62. Emerald ash borer is a quarantined pest and its movement (i.e. Emerald ash borers and infested plants or plant parts) is being regulated to help prevent further spread into uninfested areas. For more information contact your local Canadian Food Inspection Agency.

It is important to prevent borer injury, as infested plants may be damaged beyond repair before the pest makes itself known. Signs of damage include dark, discoloured or dead areas, and branches. Sap and sawdust-like borings may cling to bark and litter the ground.

Borers also provide an entrance for disease-causing fungi. They can weaken trees, making wind damage likely, and may eventually girdle and kill the tree.

Gall Makers

Galls are abnormal vegetative growths produced by a plant in response to insect irritations or stimuli. Causes include feeding, stinging, egg laying or toxin injection. This reaction generally benefits the pest by creating a protected feeding site.

Aphids, mites, midges, gall wasps and some beetles and moth larvae can all produce galls. Galls vary greatly in size, colour and complexity, but each insect species produces a characteristic gall formation. Oaks and hickories are the favourite hosts for several hundred different gall insects.

Galls may form anywhere on a tree. They adversely affect the appearance and shape of trees, and may kill leaves and branches yet rarely kill the tree.

Soil Pests

Pests below the soil line can seriously damage plants before making themselves known. It can be difficult to determine the extent of the pest problem or the effectiveness of treatment. Monitoring programs should include examination of crowns and roots below the soil, especially where symptoms of stress are evident. Some common types of soil pests are listed below.

Japanese Beetles

Japanese beetles (*Popillia japonica*) are a quarantined pest by the Canadian Food Inspection Agency (CFIA). This means that its movement (i.e. Japanese beetles and infested plants or soil) is being regulated to help prevent further spread into uninfested areas. While not a major cause of crop damage in Ontario, it is important to control infestations and prevent new ones. Established populations exist in counties of southern Ontario. Contact your local CFIA office (see Appendix D, *Other Contacts*, page 132) for a current list.

Japanese beetle larvae are "C"-shaped, milky-white grubs about 25 mm in length. They have brown heads and 3 pairs of legs. A "V"-arrangement of spines on the last abdominal segment (raster) distinguishes them from other grubs. The larvae feed on the roots of turf and nursery stock.

Managing Japanese Beetles in Nurseries

If Japanese beetles infest (or are thought to infest) your area or adult beetles are caught nearby, use these strategies to reduce injury and control grub populations:

- Watch for emerging adult beetles. The OMAF Nursery-Landscape Agriphone, 1-800-290-4441 will report when adult beetles have been found. (Also found at www.gov.on.ca/OMAF/.)

- You may trap for adult Japanese beetles beginning around the time the *Catalpa speciosa* is beginning to bloom (mid-June in southern Ontario). Note that traps are used for monitoring — not for control. To avoid attracting beetles to your nursery, place traps in nearby pastures, vacant fields or fence rows. Research shows that if you trap fewer than 4,000 beetles at peak flight you probably do not have an established larvae population (especially in clean cultivated soils).

- Scout fence rows and hedge rows once adult beetles emerge. Look for beetles feeding on leaves, especially in early morning or late afternoon. Feeding injury skeletonizes the leaf.

- Remove wild grape and other weedy host plants from the area. Adult beetles feed on different host plants than their larvae. By removing food sources, you discourage adult beetles from feeding in the area. For a list of common host plants, see OMAF Factsheet *Japanese Beetle in Nurseries and Turf,* Order No. 92-105.

- Control beetles in fence rows and hedges first. If you notice beetles feeding, apply controls before 7:00 a.m. when beetles are sluggish and slow.

- Discourage egg laying in your nursery. Japanese beetles lay eggs in turf areas such as pastures and grassy, weedy areas. Almost all grasses support larval populations, while alsike clover, crown vetch, white Dutch clover and Canadian mammoth clover do not. Eliminate suitable egg-laying sites near desirable host plants.

- If you maintain a grass strip between tree rows, consider an alternate cover crop. Research shows that you can discourage egg laying by allowing the grass to grow longer in July and August.

- Keep soil that will be dug with the plant at harvest free from weeds and grass. Provide an extra-wide clean cultivated area at the base of trees.

- Cultivating to a depth of 7.5 cm (3 in.) may destroy 25%–30% of the larvae. Cultivating is most effective in early fall and late spring.

- Low, wet, poorly drained areas and irrigated fields are preferred egg laying sites during droughts.

- Prepare "trap-turf" areas (grassy areas at the periphery of fields that attract egg laying adults). Treat these areas with insecticides in the late summer and early fall to control larvae.

- Containers are not preferred egg-laying sites. Avoid introducing eggs into a container — ensure that added soil is free of Japanese beetle eggs and larvae.

- Maintain a good weed control program in the field and in the container.

- For container grown stock: you can treat in April and May. See CFIA guidelines regarding the treatment of Japanese beetle to allow for shipping of nursery stock.

White Grubs

In addition to Japanese beetle larvae, the larvae of European chafers (*Rhizotrogus majalis*) and June beetles (*Phyllophaga* sp.) make up the group of insects called "white grubs". White grubs larvae submit into a distinctive "C" shape when uncovered in the soil. They have a brown head capsule, 3 pairs of legs and maintain a constant width throughout their abdomen. Larvae of white grubs are very similar, identification of species is made through close examination of the tiny spines on the raster (the last segment of the body). June beetle larvae have 2 parallel rows of stout spines on the raster and a "Y"-shaped anal slit. Japanese beetle larvae have 2 short rows of stout spines in a distinct "V" pattern on the raster and a crescent-shaped anal opening. European chafer larvae have 2 nearly parallel rows of spines on the raster that diverge slightly at the hind end and a "Y"-shaped anal slit. Mature June beetle larvae are the largest (up to 4 cm long), followed by European chafer (1.5 cm) and Japanese beetle (1.25 cm). The adult beetles fly and may cause feeding damage on the foliage of outdoor ornamentals.

Traditionally a pest of turf, white grub larvae have been expanding their host range. In the last few years, white grub larvae have been found feeding on the roots and crowns of woody nursery stock in the field. There have also been cases of white grubs feeding on vegetable crops and cash crops in southwestern Ontario. Monitor for grub populations in late summer. Registered insecticides are most effective when applied by early autumn as grubs are just entering their heavy feeding period and soil temperatures are still warm enough for them to feed near the surface. Some indicator species for white grubs include Japanese tree lilac, balsam fir and white spruce.

Root Weevils

Root weevils are small (up to 1 cm long), white larvae that feed on the crown and roots from under the soil. Root weevils have a brown head capsule, no legs and are fatter in the centre of their abdomen than at their hind end. Their absence of legs and uneven thickness distinguishes them from white grub larvae. The 2 most common root weevils in Ontario are black vine weevils (*Otiorhynchus sulcatus*) and strawberry root weevils (*Otiorhynchus ovatus*). Strawberry root weevils feed on white cedar while black vine weevils have a much larger ornamental host range. Adult root weevils are flightless, all female and resemble a beetle except that they have a long snout. These adults crawl around and feed during the night by cutting notches into leaves. The leaf notches rarely lead to serious damage but are an indication that a weevil population is present. Inspect crowns and roots for weevil larvae and feeding damage anytime from September through May. This is the period when weevil larvae are most likely to be present.

Weevil larvae are difficult to control with chemicals since they can be found associated with the deeper root system. Recent studies with entomopathogenic nematodes (*Heterohabditis megidis*, Nemasys H^{TM}, Heterhabditis System^{TM}) have shown excellent control of root weevils in container production, and about a 50% reduction of root weevil populations in the field. Adult weevil populations can be reduced by using registered contact insecticides applied to the foliage during the early evening. Indicator species for root weevils include *Taxus, Rhodondendron, Thuja, Heuchera* and *Sedum.*

Nematodes

Nematodes are tiny, thread-like roundworms that feed and multiply in or on a wide range of plant roots. Necrosis (small dead areas) or localized swellings in roots may indicate possible feeding sites. Nematodes may also spread soil-borne viruses and permit the development of secondary bacteria and fungus infections.

Treat potential nematode problem areas before planting using registered products such as *Vorlex, Basamid, Vapam, Telone* or *methyl bromide.* Use these materials according to the manufacturer's instructions. Control nematode diseases by rotating crops, sterilizing the soil and disinfecting dormant planting material. To sample for nematodes, see Appendix E, *Diagnostic Services*, page 133.

Consult the OMAF Web site at www.gov.on.ca/OMAF for detailed information about nematode problems, preplant soil fumigation and the fumigation of established nurseries. See *Soil Fumigants* on page 109 for more information.

Soybean cyst nematode

Soybean cyst nematode, *Heterodera glycines*, is a concern in southwestern Ontario, especially in Kent, Perth, Elgin, Essex and Prescott-Russell counties. While most field-grown nursery stock does not host this pest, practicing good soil management can help reduce its spread.

- Do not grow nursery stock on fields recently used to produce soybeans.
- Do not employ equipment in nursery fields that was used to work soybean fields. Attached soil can spread the nematode cysts.
- Prevent soil erosion.
- Many weeds act as host plants to soybean cyst nematode. Good weed control will reduce populations.
- Nematicides are ineffective against this pest.

Use Table 3–1 to identify insect injuries to nursery and landscape plants from plant damage.

TABLE 3–1. Host Symptoms and Possible Causes of Insect Injury

Category	Symptom	Possible Causes
Chewed leaves and/or chewed flowers	➢ Pieces of leaf or flower missing ➢ Entire leaves or flowers missing	Caterpillars (moth larvae, butterfly larvae) Larvae or adult beetles Sawfly larvae Grasshoppers Snails Slugs
Discoloured leaves	➢ Bleached leaves ➢ Bronzed leaves ➢ Silvered leaves ➢ Stippled leaves ➢ Streaked leaves	Lace bugs Plant bugs Spider mites Leafhoppers Aphids Psyllids Thrips
Plant part distortion	➢ Mined leaves ➢ Skeletonized leaves ➢ Curled/cupped leaves ➢ Galls on leaves, stems, flowers, twigs ➢ Twisted growing points	Beetle larvae Caterpillars Sawflies Aphids Gall wasps Gall flies Psyllids Eriophyid mites
Plant dieback	➢ Dying leaves, twigs, branches ➢ Dying whole plant ➢ Holes and frass observed ➢ Wilting	Twig pruners Root feeding beetle larvae Boring insects Scales Adelgids

Use Table 3–2 to identify insect injuries to nursery and landscape plants from visible insect matter.

TABLE 3–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)

Symptom	Possible Causes	Symptom	Possible Causes
➢ Dark fecal spots	Aphids Soft scales Leafhoppers Mealy bugs Psyllids Whiteflies	➢ Cast skins	Aphids Cicadas Clearwing moth larvae Lacebugs Leafhoppers
➢ Honeydew ➢ Sooty mould	Lacebugs Greenhouse thrips Some plant bugs Sawfly adults	➢ Pitch mass	Larvae of certain kinds of moths and beetles
➢ Silken mats ➢ Spittle ➢ Tents ➢ Webs	Leaf rollers Leaftiers Spittlebugs Tent caterpillars Webworms	➢ Flocculence (cottony waxy material)	Adelgids Aphids Certain scales Mealybugs Psyllids
➢ Sap flow	Larvae of certain kinds of moths and beetles	➢ Slime	Slugs Snails
➢ Pitch tubes	Bark beetles		

Phenology & Growing Degree Day Tables for Monitoring

The following tables describe some of the more common insect and mite pests present in Ontario nurseries and landscapes. Table 3–3 is a list of phenology plants whose fruiting and flowering characteristics are used to indicate the emergence and development of certain insect pests; these correlate with Growing Degree Day (GDD) summary models. For more detailed information regarding GDDs, see *Monitoring* on page 31. The remaining tables outline phenology plant characteristics, GDD summaries and pest descriptions to help in planning your monitoring for plant pests in the outdoor nursery and landscape. The presence of a "V" in the Stage column indicates this pest is vulnerable to chemical control (which may include dormant oil) at this time.

Obtain the daily maximum and minimum temperatures needed to calculate GDDs from weather stations such as Ontario Weather Network and Environment Canada or extract them from on-farm weather stations. The OMAF Nursery-Landscape Agriphone contains GDD accumulations for some of the concentrated nursery growing regions of Ontario. The OMAF Nursery and Landscape Agriphone message is available on the OMAF Web site (www.gov.on.ca/OMAF) or call 1-888-290-4441 to listen to the telephone recording (from April to October).

TABLE 3–3. Common Phenology Plant Indicators for Ontario

Acer platanoides	Norway maple
Acer rubrum	red maple
Acer saccharinum	silver maple
Acer saccharum	sugar maple
Aesculus hippocastanum	horsechestnut
Aesculus parviflora	bottlebrush buckeye
Amelanchier laevis	serviceberry, shadberry
Catalpa speciosa	northern catalpa
Cercis candensis	redbud
Cirsiom arvense	Canada thistle
Cornus alternifolia	pagoda dogwood
Cornus mas	cornelian cherry dogwood
Crataegus phaenopyrum	Washington hawthorn
Daucus carota	wild carrot, Queen Anne's lace
Gleditsia triacanthos	honeylocust
Hamamelis vernalis	spring-blooming witchhazel
Hamamelis virginiana	fall-blooming witchhazel
Hydrangea arborescens 'Grandiflora'	hills of snow hydrangea
Hydrangea paniculata 'Grandiflora'	panicle hydrangea
Kolkwitzia amabilis	beautybush
Lonicera korolkowii 'Zabelii'	zabel honeysuckle
Lonicera tatarica	tartarian honeysuckle
Magnolia x soulangiana	saucer magnolia
Philadelphus	mockorange
Pinus mugo	mugo pine
Prunus x cistena	purpleleaf sand cherry
Prunus serotina	wild black cherry
Prunus triloba	flowering almond
Ribes odoratum	golden or flowering currant
Robinia pseudoacacia	black locust
Salix caprea	pussy willow
Sambucus canadensis	American elder, elderberry
Solidago canadensis	Canada goldenrod
Sorbus ausuparia	European mountain ash
Spiraea nipponica 'Snowmound'	snowmound spiraea
Spiraea x vanhouttei	bridal wreath spiraea
Syringa reticulata	Japanese tree lilac
Syringa villosa	late lilac
Syringa vulgaris	common lilac
Ulmus pumila	Siberian elm
Viburnum carlesii	Koreanspice viburnum
Viburnum dentatum	arrowwood viburnum
Viburnum lantana	wayfaring tree viburnum
Viburnum opulus	European cranberrybush viburnum
Weigela florida	old-fashioned weigela
Yucca filamentosa	Adam's needle

TABLE 3–4. Monitoring for Late March/Early April (1–25 GDD Base 10°C)

Green Leaf Bud Stage	**Flower Bud**	**Starting Bloom**	**Full Bloom**
Gleditsia triancanthos	*Syringa vulgaris*	*Acer saccharum*	*Acer saccharinum*
Syringa vulgaris		*Acer rubrum*	
		Cornus mas	
		Salix caprea	

Plant	**Pest**	**Stage**
Apple, cherry, crabapple, hawthorn	Eastern tent caterpillar	Overwintering egg mass on small twigs
Elm	Elm bark beetle	Adults (V), eggs under bark
Maple	Gall mites and wasps	Adults (V), eggs on new leaves
Pine	Pine bark aphid	Overwintering eggs, hatching nymphs (V)
Pine	Pine shoot beetle	Adults (V), eggs under bark
Pine	White pine weevil	Adults (V) in leaf litter, on terminals
Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds becoming active
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that looked damaged last year
Various deciduous trees	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects

TABLE 3–5. Monitoring for Mid-April to Late April (25–55 GDD Base 10°C)

Green Leaf Bud Stage	**Flower Bud**	**Mid Bloom**	**End Bloom**	**New Leaves**
Syringa vulgaris	*Acer platanoides*	*Acer rubrum*	*Acer saccharinum*	*Ulmus pumila*
Gleditsia triacanthos	*Amelchier laevis*	*Cornus mas*		
	Magnolia x soulangiana	*Forsythia* sp.		
		Magnolia stellata		
		Salix caprea		

Plant	**Pest**	**Stage**
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	New larvae (V), tiny tents
Birch	Birch leafminer	Look for tiny, black sawfly adults around new leaves (sticky traps)
Elm	Elm bark beetle	Adults (V), eggs under bark
Evergreens	Spruce budworm	Larvae (V)
Fir		
Maple	Gall mites and wasps	Adults (V), eggs on new leaves
Pine	Pine bark aphid	Overwintering eggs, hatching nymphs
Pine	Pine shoot beetle	Adults, eggs under bark
Pine	White pine weevil	Adults (V), eggs on terminals
Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
Pine	Zimmerman pine moth	Overwintering larvae
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds (V)
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that looked damaged last year (dormant oil)
Various deciduous trees	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects
Various nursery stock in field	White grubs	Look for C-shaped grubs in soil around damage roots
Viburnum	Viburnum leaf beetle	Inspect twig undersides for rows of brown bumps (egg sites) and prune out

TABLE 3–6. Monitoring for Late April to Mid May (55–100 GDD Base 10°C)

Leafing out	Flower Bud	Early Bloom	Full Bloom
Acer saccharinum	*Aesculus hippocastanum*	*Amelanchier laevis*	*Acer platanoides*
Ulmus pumila	*Gleditsia triacanthos*	*Cercis candensis*	*Acer saccharum*
	Spiraea x vanhouttei	*Cornus florida*	*Magnolia x soulangiana*
	Syringa vulgaris	*Viburnum carlesii*	*Prunus x cistena*

Plant	Pest	Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V), remove tents
Birch	Birch leafminer	Look for small blotches in leaves (larvae)
Cedar	Fletcher scale	Nymphs (V)
Dogwood	Dogwood borer	Inspect trunk and large branches for holes and fresh sawdust. Destroy larvae.
Euonymus	Euonymus webworm	Inspect shoot for yellow larvae and webbing (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Evergreens	Spruce budworm	Larvae (V)
Evergreens	Spruce spider mite	Hatching nymphs (V)
Fir	Balsam twig adelgid	Nymphs (V)
Honeylocust	Honeylocust pod gall midge	Adults (V), monitor with sticky cards
Lilac	Lilac borer	Inspect trunk and large branches for holes and fresh sawdust (destroy larvae)
Maple	Gall mites and wasps	Adults, eggs on new leaves
Pine	European pine sawfly	Look for small, green larvae on new growth (V)
Pine	White pine weevil	Larvae in terminals (prune out)
Pine	Pine bark aphid	Nymphs (V)
Pine	Zimmerman pine moth	Overwintering larvae (V)
Pine	Pine spittlebug	Look for spittle masses on new growth, remove by hand
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper, look for mites
Spruce	Cooley and eastern spruce gall adelgid	Nymphs next to buds (V)
Various deciduous trees and shrubs	Scales, adelgids, mealybugs, mites	Inspect plants that looked damaged last year (dormant oil)
Various deciduous trees	Gypsy moth	Eggs masses beginning to hatch
Various nursery stock in field	White grubs	Look for C-shaped grubs in soil around damage roots
Viburnum	Viburnum leaf beetle	Inspect egg sites and leaf undersides for hatching larvae (V)
Viburnum	Snowball aphid	Inspect new leaves for nymphs (V)
Yew	Fletcher scale	Nymphs (V)

TABLE 3–7. Monitoring for Mid-May to Late May (100–150 GDD Base 10^{0}C)

Early Bloom	**Full Bloom**	**Late Bloom**
Prunus serotina	*Aesculus hippocastanum*	*Amelanchier laevis*
Sorbus aucuparia	*Gleditsia triacanthos*	*Cercis candensis*
	Lonicera korolkowii	
	Ribes odoratum	
	Spiraea x vanhouttei	
	Syringa vulgaris	
	Viburnum lantana	

Plant	**Pest**	**Stage**
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V), remove tents
Birch	Birch leafminer	Look for small blotches in leaves (larvae) (V)
Boxwood	Boxwood psyllid	Inspect for waxy, white nymphs on new foliage
Cedar	Cedar leaf miner	Look for small, greyish-white adult moths when foliage is disturbed (V)
Euonymus	Euonymus webworm	Inspect shoot for yellow larvae and webbing (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Evergreens	Spruce spider mite	Hatching nymphs (V)
Fir	Balsam twig adelgid	Nymphs (V)
Lilac	Lilac borer	Inspect trunk and large branches for holes and fresh sawdust (destroy larvae)
Lilac	Lilac leafminer	Look for new mines in leaves (larvae) (V)
Maple	Gall mites and wasps	Larvae hatching
Pine	European pine sawfly	Look for small, green larvae on new growth (V)
Pine	Pine needle scale	Egg hatch
Pine	White pine weevil	Larvae in terminals (prune out)
Pine	Pine spittlebug	Look for spittle masses on new growth, remove by hand
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper and look for tiny, slow mites
Various deciduous trees	Gypsy moth	Larvae (V)
Various nursery stock in field	White grubs	Look for C-shaped grubs in soil around damage roots
Viburnum	Viburnum leaf beetle	Inspect egg sites and leaf undersides for hatching larvae (V)
Viburnum	Snowball aphid	Inspect new leaves for nymphs (V), only susceptible 1–10 days after egg hatch
Yew	Taxus mealybug	Look for small, whitish nymphs (V) in branch crotches

TABLE 3–8. Monitoring for Late May to Early June (150–200 GDD Base 10°C)

Early Bloom
Cornus alternifolia
Prunus serotina
Viburnmu opulus

Ripe seed
Ulmus pumila

Dropping seed
Acer saccharinum

Full Bloom
Aesculus hippocastanum
Lonicera korolkowii
Prunus serotina
Sorbus aucuparia
Spirea x vanhouttei
Syringa vulgaris

Late Bloom
Aesculus hippocastanum
Gleditsia triacanthos
Lonicera korolkowii
Ribes odoratum
Viburnum lantana

Candling (6–8 in.)
Pinus mugo

Plant	**Pest**	**Stage**
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V), remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Birch leafminer	Look for small blotches in leaves (V)
Birch	Bronze birch borer	Treat bark with registered contact insecticides, before eggs are laid
Boxwood	Boxwood psyllid	Inspect for waxy, white nymphs
Cedar	Cedar leaf miner	Small, greyish-white adult moths when foliage is disturbed (V)
Euonymus	Euonymus webworm	Inspect shoot for yellow larvae and webbing (V)
Deciduous trees	Fall cankerworm	Larvae (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Honeylocust	Honeylocust plant bug	Shake new foliage over white paper, look for tiny, green plant bugs (V)
Holly	Holly leafminer	Use sticky traps to trap small, grey, adult flies (V)
Lilac	Lilac borer	Adult flight, mating and egg-laying, treat trunk and large branches with registered pesticides
Lilac	Lilac leafminer	Look for new mines in leaves (larvae) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Pine	European pine sawfly	Look for small, green larvae on new growth (V)
Pine	Pine needle scale	Look for tiny, red crawlers (V)
Pine	White pine weevil	Larvae in terminals (prune out)
Pine	Pine spittlebug	Look for spittle masses on new growth, remove by hand
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper and look for tiny, slow mites
Various deciduous trees	Gypsy moth	Larvae (V)
Various nursery stock in field	White grubs	Look for C-shaped grubs in soil around damage roots
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Taxus mealybug	Look for small, whitish nymphs (V) in branch crotches

TABLE 3–9. Monitoring for Early June to Mid-June (200–250 GDD Base 10°C)

Early Bloom
Spiraea nipponica
Viburnum dentatum
Weigela florida

Ripe seed
Ulmus pumila

Dropping seed
Acer saccharinum

Full Bloom
Aesculus hippocastanum
Cornus alternifolia
Lonicera korolkowii
Prunus serotina
Robinia pseudoacacia
Sorbus aucuparia
Spirea x vanhouttei
Syringa vulgaris
Viburnmu opulus

Late Bloom
Aesculus hippocastanum
Gleditsia triacanthos
Lonicera korolkowii
Ribes odoratum
Viburnum lantana

Candling (6–8 in.)
Pinus mugo

Plant	**Pest**	**Stage**
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V), remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Birch leafminer	Examine second flush of leaves for small blotches in leaves (V)
Birch	Bronze birch borer	Finish bark applications, before eggs are laid
Boxwood	Boxwood psyllid	Inspect for waxy, white nymphs on new foliage
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Cedar	Cedar leaf miner	Look for small, greyish-white adult moths when foliage is disturbed (V)
Elm	Elm leaf beetle	Larvae cause holes and skeletonized foliage (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Honeylocust	Honeylocust plant bug	Shake new foliage over white paper, look for tiny, green bugs (V)
Holly	Holly leafminer	Use sticky traps to trap small, grey, adult flies (V)
Larch	Larch casebearer	Adult moths are tiny with dark wings, easily disturbed
Lilac	Lilac borer	Adult flight, mating and egg-laying, treat trunk and large branches with registered pesticides (V)
Lilac	Lilac leafminer	Look for new mines in leaves (larvae) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Mountain Ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Look for tiny, red crawlers (V)
Pine	White pine weevil	Larvae in terminals (prune out)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper and look for tiny, slow-moving mites
Various deciduous trees	Gypsy moth	Larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Look for early emergence of overwintering adults (V)
Yew	Taxus mealybug	Look for small, whitish nymphs (V) in branch crotches

TABLE 3–10. Monitoring for Mid-June (250–300 GDD Base 10°C)

Early Bloom	**Full Bloom**	**Late Bloom**
Philadelphus	*Cornus alternifolia*	*Aesculus hippocastanum*
Kolkwitzia amabalis	*Robinia pseudoacacia*	*Lonicera korolkowii*
	Spiraea nipponica	*Prunus serotina*
Ripe seed	*Viburnum dentatum*	*Sorbus aucuparia*
Ulmus pumila	*Viburnmu opulus*	*Spirea x vanhouttei*
	Weigela florida	*Syringa vulgaris*
Dropping seed		
Acer saccharinum		

Plant	**Pest**	**Stage**
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Larvae (V), remove tents
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Bronze birch borer	Finish bark applications, before eggs are laid
Birch	Birch leafminer	Examine second flush of leaves for small blotches in leaves (larvae) (V)
Boxwood	Boxwood psyllid	Inspect for waxy, white nymphs on new foliage
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Cedar	Cedar leaf miner	Look for small, greyish-white adult moths when foliage is disturbed (V)
Cherry	Peach tree borer	Newly hatched larvae (V)
Elm	Elm leaf beetle	Larvae cause holes and skeletonized foliage (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Holly	Holly leafminer	Use sticky traps to trap small, grey, adult flies (V)
Larch	Larch casebearer	Adult moths are tiny with dark wings, easily disturbed
Lilac	Lilac borer	Adult flight, mating and egg-laying, treat trunk and large branches with registered pesticides (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Look for tiny, red crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper and look for tiny, slow-moving mites
Various deciduous trees	Gypsy moth	Larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Look for early emergence of overwintering adults (V)
Yew	Taxus mealybug	Look for small, whitish nymphs (V) in branch crotches

TABLE 3–11. Monitoring for Mid-June to Late June (300–400 GDD Base 10^{0}C)

Early Bloom	**Full Bloom**	**Late Bloom**
Catalpa speciosa	*Catalpa speciosa*	*Aesculus hippocastanum*
Syringa reticulata	*Syringa reticulata*	*Cornus alternifolia*
Syringa villosa	*Kolkwitzia amabalis*	*Kolkwitzia amabalis*
	Philadelphus	*Robinia pseudoacacia*
	Viburnum dentatum	*Spiraea nipponica*
		Viburnmu opulus

Plant	**Pest**	**Stage**
Ash and other deciduous trees	Oystershell scale	Crawlers (V)
Birch	Bronze birch borer	Larvae hatching, boring into bark
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Cedar	Cedar leaf miner	Look for small, greyish-white adult moths when foliage is disturbed (V)
Cherry	Peach tree borer	Newly hatched larvae (V)
Elm	Elm leaf beetle	Larvae cause holes and skeletonized foliage (V)
Euonymus	Euonymus scale	Look for tiny, orange crawler on twigs and leaf undersides (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Juniper	Juniper scale	Nymphs are tiny, yellow (V)
Larch	Larch casebearer	Adult moths are tiny with dark wings, easily disturbed
Mountain Ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Spruce	Spruce spider mite	Hatching nymphs (V), shake branch over paper and look for tiny, slow-moving mites
Yew	Black vine weevil	Look for early emergence of overwintering adults (V)

TABLE 3–12. Monitoring for Late June to Early July (400–500 GDD Base 10°C)

Early Bloom	**Full Bloom**	**Late Bloom**
Cirsium arvense	*Catalpa speciosa*	*Philadelphus*
Hydrangea arborescens 'Grandiflora'		*Syringa reticulata*
Sambucus canadensis	**Fruiting**	*Weigela florida*
	Amelanchier laevis	
	Lonicera tartarica	

Plant	Pest	Stage
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Look for tiny, orange crawler on twigs and leaf undersides (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Juniper	Juniper scale	Nymphs are tiny, yellow (V)
Maple	Cottony maple scale	Crawlers hatching (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Yew	Black vine weevil	Look for early emergence of new progeny adults (V)

TABLE 3–13. Monitoring for Early July to Mid-July (500–700 GDD Base 10°C)

Early Bloom	**Full Bloom**	**Late Bloom**
Cichorium intybus	*Cirsium arvense*	*Catalpa speciosa*
Daucus carota	*Daucus carota*	*Hydrangea arborescens* 'Grandiflora'
	Hydrangea arborescens 'Grandiflora'	*Yucca filamentosa*
Fruiting	*Sambucus canadensis*	
Lonicera tartarica	*Yucca filamentosa*	

Plant	Pest	Stage
Ash, other deciduous trees	European fruit lecanium scale	Crawlers (V)
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Cedar	Fletcher scale	Crawlers (V)
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Elm	European elm scale	Crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Juniper	Juniper scale	Nymphs are tiny, yellow (V)
Maple	Cottony maple scale	Crawlers on leaves and twigs (V)
Mountain Ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)

TABLE 3–13. Monitoring for Early July to Mid-July (500–700 GDD Base 10°C) (Cont'd)

Roses, grape vine	Japanese beetle	Adult beetle skeletonize foliage (V)
Spruce	Spruce bud scale	Crawlers (V)
Various ornamentals	Leafhoppers	Monitor Caragana and hoptree as indicator plants, treat with insecticides at first sign (V)
Yew	Fletcher scale	Crawlers (V)
Yew	Black vine weevil	Look for early emergence of new progeny adults (V)

TABLE 3–14. Monitoring for Mid-July to Late July (700–900 GDD Base 10°C)

Early Bloom	**Full Bloom**	**Late Bloom**
Cichorium intybus *Daucus carota*	*Daucus carota*	*Daucus carota*
	Fruiting	
	Viburnum lantana	
Fruit Yellow	**Ripe Seed**	**White Flowers to Green**
Sorbus aucuparia	*Cirsium arvense*	*Hydrangea arborescens* 'Grandiflora'
Plant	**Pest**	**Stage**
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches, manually remove
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Pine	Pine needle scale	Second generation Crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Roses, grape vine	Japanese beetle	Adult beetle skeletonize foliage (V)
Various ornamentals	Leafhoppers	Monitor Caragana and hoptree as indicator plants, treat with insecticides at first sign (V)
Yew	Black vine weevil	Look for early emergence of new progeny adults (V)

TABLE 3–15. Monitoring for Early August to Late August (900–1,100 GDD Base 10^{0}C)

Early Bloom	**Full Bloom**	**Late Bloom**
Solidago canadensis	*Hydrangea paniculata* 'Grandiflora' *Solidago canadensis*	*Hydrangea paniculata* 'Grandiflora'
		Fruiting
Fruit Orange		*Viburnum lantana*
Sorbus aucuparia		*Viburnum opulus*
Plant	**Pest**	**Stage**
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches, manually remove
Cedar	Strawberry root weevil	Adult weevil feed on new shoots, girdling them at the base
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second generation of Crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Magnolia	Magnolia scale	Egg hatch just beginning
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Roses, grape vine, various ornamentals	Japanese beetle	Adult beetle skeletonize foliage
Various ornamentals	Leafhoppers	Monitor Caragana and hoptree as indicator plants, treat with insecticides at first sign (V)
Yew	Black vine weevil	Look for early emergence of new progeny adults (V)

TABLE 3–16. Monitoring for Late August to Mid-September (1,100–1,300 GDD Base 10^{0}C)

Early Bloom	**Full Bloom**	**Late Bloom**
		Solidago canadensis
Fruit Orange	**White Flowers to Pink**	
Sorbus aucuparia	*Hydrangea paniculata* 'Grandiflora'	
Plant	**Pest**	**Stage**
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches, manually remove
Deciduous trees (linden, sycamore, tuliptree, apple)	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second generation of Crawlers (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Magnolia	Magnolia scale	Crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves, feeding causes yellow spots (V)
Roses, grape vine, various ornamentals	Japanese beetle	Adult beetle skeletonize foliage
Various ornamentals	Leafhoppers	Monitor Caragana and hoptree as indicator plants, treat with insecticides at first sign (V)

TABLE 3–17. Monitoring for Mid-September to Late October (1,300–1,700 GDD Base 10°C)

Early Bloom	**Full Bloom**	**Late Bloom**
Hamamelis virginiana *Solidago* sp.	*Hamamelis virginiana* *Solidago* sp.	*Solidago canadensis*
Fruiting	**Fall Foliage Colour**	**Ripe Seed**
Viburnum dentatum	*Acer saccharum*	*Daucus carota*

Plant	Pest	Stage
Apple, crabapple, cherry, hawthorn	Eastern tent caterpillar	Look for shiny, grey egg mass bands on small twigs (prune out)
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches, manually remove
Cherry	Peach tree borer	Examine cankered regions for larvae, remove infested plants
Evergreens	Spruce spider mite	Shake branches over white paper, look for tiny, slow-moving mites (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper, see tiny, reddish-brown mites (V)
Pine	Zimmerman pine moth	Larvae (V)
Spruce	Cooley and Eastern spruce gall adelgid	Look for tiny, grey, fuzzy nymphs next to buds, (Vulnerable when the *Acer saccharum* are in fall colour)
Spruce	Spruce spider mite	Shake branches over white paper, look for tiny, slow-moving mites (V)
Various woody ornamentals	Overwintering insects and mites	Look for overwintering scales, mites, mealybugs and adelgids and flag the plants for dormant oil application

Diseases Affecting Trees and Shrubs

Diseases are broadly classified according to the types of damage they cause to woody plants.

- Foliage diseases
- Crown and root rots
- Cankers
- Vascular wilts
- Viruses
- Abiotic diseases

Diseases arise from many causes such as bacteria, fungi, moulds, viruses and environmental conditions. Some common nursery and landscape plant diseases are listed below; see *A Compendium of Pests and Diseases with Recommended Management Practices* on page 62.

Foliage Diseases

Most disease symptoms appear first in plant foliage, however, damaged foliage may not imply a "leaf disease." Leaves may wilt, turn yellow or brown, spot, drop off or deform due to diseases not directly associated with the leaves. For example, plant foliage can change in response to vascular wilts or cankers elsewhere on the plant. Non-infectious agents, such as drought and air pollution, also display their first symptoms in the foliage.

Downy mildew, powdery mildew, leaf spots, anthracnose and needlecast are common diseases that infect foliage directly. Rust diseases that cause leaf spots on broadleaf hosts are discussed under "cankers."

Botrytis (Grey Mold)

This disease, caused by the fungus *Botrytis cinerea*, can affect bulbs, stems, leaves and flowers. It often attacks open or fading flowers and leaves, succulent soft growth and damaged tissue. Symptoms vary from host to host. In very humid air, *Botrytis* causes a fuzzy grey growth on infected plant parts.

High humidity promotes *Botrytis* outbreaks. Reduce humidity by providing good air circulation around your plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day and never leave old leaves or flowers on plants or on the surrounding soil surface.

Downy Mildew

Downy mildew appears early in the season. It often covers the undersides of leaves with a heavy, white, downy fungus growth. Discoloured, purplish spots may appear on the surface of the leaves.

Warm or cool wet weather and poor air circulation promote downy mildew. Reduce humidity by providing good air circulation around your plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day and never leave old leaves or flowers on plants or on the surrounding soil surface.

Powdery Mildew

Several species of fungi cause powdery mildew. Powdery mildews produce powdery white mats on upper leaf surfaces and young tissue. Wind-borne spores can cause secondary infections, though individual species do not spread readily from one kind of plant to another.

Powdery mildew usually appears after mid-season when warm days follow cooler nights. It affects many woody ornamentals, such as *Syringa, Rosa, Ligustrum* and *Catalpa*. Because the fungus grows mainly on the plant surface, it can be controlled with fungicides. In some cases, as with roses, severe deformation requires control. In others, such as with lilacs and privets, the disease is not damaging enough to warrant fungicide applications.

To reduce powdery mildew, place plants in sunny locations with good air circulation. Where possible, plant resistant cultivars. Overhead watering *during the day* may reduce the spread and development of powdery mildew. Avoid overhead irrigation late in the day.

Leaf Spot and Anthracnose

"Anthracnose" refers to several plant diseases that cause dead spots on leaves or fruits. This disease may also affect the twigs, causing a canker and dieback. Infected areas may coalesce into large necrotic spots as the disease spreads. In severe cases, this condition defoliates the plant. Leaf spotting itself is not harmful, however extensive annual defoliation can lead to plant decline and death.

Cool, wet, cloudy spring weather promotes infection by fungi that cause leaf spot and anthracnose. *Catalpa, Populus, Juglans, Carya, Crataegus, Acer, Quercus, Platanus* (Sycamore), *Philadelphus, Sorbus* and *Aesculus* are common hosts. Sycamore anthracnose (*Gnomonia plantani)* can be severe in Ontario and has killed many trees in the eastern United States.

Needlecast

Needlecast diseases are fungi affecting pines (*Pinus*), spruce (*Picea*) and firs (*Abies*). New needles generally become infected just after the new growth starts. Characteristic black fruiting bodies then develop along the needles. Needles infected the previous season are "cast" (i.e. fall off) during the summer. Needlecast can be serious in 1–4 year old plants at Ontario tree nurseries.

Apple Scab

"Scab" describes a fungus disease on fruit, though a leaf spot similar to rose blackspot has the same cause. Diseases causing scab-like lesions occur frequently on rosaceous plants.

Apple scab (*Venturia inaequalis*) has defoliated crabapples extensively when cool, wet weather occurs in mid-to-late spring. Control apple scab through cultural practices. Plant the trees in open sunny areas with good air movement and maintain their health. Prune the trees regularly to encourage quick leaf drying. Since the disease overwinters on fallen leaves, collect these leaves in the late summer and fall each year. Remove the collected leaves from the growing area. This practice may prove ineffective if other diseased trees exist in adjacent areas. If leaf removal is not possible, try using a mower to mulch leaves as they drop throughout the autumn season. The smaller leaf sections will accelerate bacterial breakdown, resulting in fewer fungal fruiting bodies to produce infective spores the following spring.

With proper culture, apple scab rarely requires chemical control. Where possible, plant scab resistant crabapple selections. If cool, wet weather persists and/or scab symptoms begin to appear, apply registered fungicides. Apply the first spray when the green leaf tips appear. Repeat every 7–10 days until the *Catalpa speciosa* begin bloom (end of June). If no scab appears by then, stop spraying. If scab is visible, continue fungicide applications every 10–14 days until mid-August.

Pyracantha scab

Pyracantha scab (*Venturia pyracanthae*) destroys the fruit of susceptible firethorn varieties. Spraying is necessary most years. The cultivars 'Orange Glow', 'Orange Charmer' and 'Mohave' resist this scab.

Crown and Root Rots

Soil fungi such as *Pythium* and *Phytophthora* cause the roots and crowns of many plants to rot. The lower leaf parts, petioles and stems of diseased plants develop a water soaked appearance. Eventually, the plant rots off at ground level. Protectant fungicides (such as Subdue MAXX) can be incorporated into the media at time of potting to reduce *Pythium* and *Phytophthoa* diseases of ornamentals.

Rhizoctonia and *Fusarium* fungi cause a brown cankering of plant stems and roots below ground.

Thielaviopsis causes severe root rot in infected plants. *Thielaviopsis* infections can be distinguished from other infections as the affected tissues are more black than brown. When this condition affects seedlings, the disease is called "damping-off."

Cankers

Cankers kill bark and cambial tissues in localized branch and stem areas. Bark in affected areas splits as it dries and is easily removed, exposing the wood below. Subsequently, the underlying cambium and wood is killed. Fruiting "pustules" of the disease organism usually form on the dead bark areas. Cankers may girdle a stem or branch, killing discreet portions of the plant.

Canker diseases can be annual or perennial. They commonly damage hosts weakened by factors such as drought, poor hardiness, root disturbance or a poor root environment. Weak, parasitic fungi (species of *Cytospora, Nectria, Valsa and Hypoxylon*) cause damaging canker diseases that a healthy, vigorous host would resist (by "sealing off" the infecting agent). While fungi account for most cankers, sunscald and frost may also be responsible.

Some canker diseases (e.g., white pine blister rust, chestnut blight and butternut canker) are very serious. "Monoculture" growing systems used in plantations and forest nurseries may promote serious canker diseases.

Chemical control for canker diseases is rarely recommended since removing cankered areas controls most cankers. Try pruning diseased branches well below the affected areas. Improve host health and vigour via cultural means for long term control.

Rust

Rust diseases involve fungi that cause reddish-brown (rusty) spots on leaves, twigs or stems. They frequently distort the shape of infected plant parts. Some rusts have one host plant. However, most rusts require two hosts, each at a different phase of their life cycle. While both hosts are necessary for the disease organism to thrive, one host plant may be severely damaged while the other suffers little or no damage.

Bacterial Blights

Fire blight, a bacterial disease caused by *Erwinia amylovora*, affects many members of the *Rosaceae* family including *Amelanchier, Aronia, Chaenomeles, Cotoneaster, Crataegus, Malus Photinia, Prunus, Pyracantha, Pyrus, Sorbus* and *Spiraea*. Flowers, spurs, twigs and leaves turn brown and dry out. Dead leaves remain on the plant and appear scorched. In warm, humid weather, an amber material may exude from recently infected parts. Bleeding perennial cankers may appear on limbs, trunks or roots as the infection spreads. Fire blight infections can be severe if conditions are cool and wet when the host trees are blooming. Rain, wind and insects can spread this disease from plant to plant. Control fire blight by pruning cankers 0.3 m [1 ft.] below the affected area and removing nearby infection sources (e.g., neglected apple or pear trees). Always disinfect pruning instruments after each cut. Bactericidal sprays at flowering may be helpful.

Bacterial canker (*Pseudomonas syringae* pv. *syringae*) has been linked to dieback on container nursery stock. Many deciduous, woody shrubs have been found to be susceptible to this bacteria, including lilacs (*Syringa*), mock orange (*Philadelphus*) and ornamental *Prunus* sp. Symptoms first appear as container stock is uncovered in the spring, revealing blackened shoots and buds that have been killed. Recent research indicates that extreme changes in temperature, coupled with extended leaf wetness periods seem to encourage the development of bacterial canker in container production. Some growers have reduced disease incidence by installing drip irrigation systems and delaying the removal of poly cover over high value, susceptible stock. Applications of bactericides after leaves drop in the autumn, and again as the buds begin to swell and break during spring, can help reduce disease pressure.

Crown Gall

The bacterium *Agrobacterium tumefaciens* causes rough, irregular galls up to several centimetres in size. Crown gall can affect most woody plants, including rosaceous hosts, euonymus and nut trees. It occurs mainly near the soil line at the root collar, but also on roots and aerial parts. While not a "true" canker disease, crown gall is included in this section because it disrupts the plant's vascular system, resulting in girdling.

The bacterium enters through wounds (e.g., from a disc, hoe or grafting knife) and can live in the soil without host plants for about 2 years. Nurseries should use sanitary propagation practices such as sterilizing grafting tools after each cut. Remove or replace infested soils, or leave fallow for 2 years before replanting. Chemical controls are not always effective.

Vascular Wilts

Fungi or bacteria entering a plant's vascular system can reduce water supplied to the leaves, causing wilt. In the early stages of wilt, leaves may recover temporarily during cool, moist periods. Eventually, the wilt becomes established and the leaves and twigs die, leading to branch mortality and the eventual death of the entire plant. Serious vascular wilt diseases include "Dutch elm disease" (*Ceratocystis ulmi*) and *Verticillium* wilt of Acer, Tilia and Catalpa (*Verticillium dahliae*).

To avoid wilt diseases, use resistant plant varieties and grow susceptible crops in disease-free soil. See Table 3–18, *Woody Plants Susceptible to Verticillium Wilt* and Table 3–19, *Woody Plants Resistant to Verticillium Wilt*, on page 56. You can sometimes maintain *Verticillum* wilt-infected plants by improving vigour through pruning, fertilizing and watering. Since these disease organisms live deep inside the plant, surface application of fungicides will not be effective.

TABLE 3–18. Woody Plants Susceptible to Verticillium Wilt

Acer	maple
Aesculus	buckeye, horsechestnut
Amelanchier	serviceberry
Buxus	boxwood
Calluna	heath
Catalpa	catalpa
Ceris	red bud
Cladrastus	yellowwood
Cotinus	smokebush
Daphne	daphne
Eleagnus	Russian olive
Fraxinus	ash
Gymnocladus	Kentucky coffee tree
Hibiscus	hibiscus
Kolreutria	golden rain tree
Ligustrum	privet
Liriodendron	tulip tree
Lonicera	honeysuckle
Magnolia	magnolia
Phellodendron	cork tree
Prunus	cherry and other stone fruit
Rhododendron	azalea
Rhus	sumac
Ribes	currant, gooseberry
Robinia	black locust
Rosa	rose
Sambucus	elder
Spireae	spirea
Syringa	lilac
Ulmus	elm
Viburnum	viburnum
Vitis	grape vine
Wiegela	wiegela

TABLE 3–19. Woody Plants Resistant to Verticillium Wilt

All monocots (grass like) plants	
All conifers	
The following broadleaf plants:	
Betula	birch
Carya	hickory
Celtis	hackberry
Cercidiphyllum	katsura tree
Chaenomeles	flowering quince
Cornus	dogwood
Crataegus	hawthorn
Fagus	beech
Gleditsia	honeylocust
Ilex	holly
Juglans	bitternut, walnut
Liquidumbar	sweetgum
Malus	apple, crabapple
Morus	mulberry
Platanus	plane tree, sycamore
Populus	poplar
Pyracantha	firethorn
Pyrus	pear
Quercus	oak
Rhododendron	rhododendron
Salix	willow
Sorbus	mountain ash
Tilia	linden
Zelkova	Japanese zelkova

Virus Diseases

Virus diseases appear on plants as mottled yellow foliage, misshapen or wrinkled leaves, aborted flowers or stunted growth. You must remove these diseased plants and destroy them.

Insects and infected tools (e.g., pruning equipment, knives, shears) spread most of the virus diseases. *You cannot control viruses directly by chemical means.* When you suspect a virus, disinfect all tools and implements before using them again. Samples of symptomatic plants can be sent to the *Pest Diagnostic Clinic* (see Appendix E) to analyze tissue for virus particles. Destroy infested plants where possible, to prevent further spread to other susceptible crops. Controlling aphids, leafhoppers, mites and other migratory insects also helps prevent viral spread. Viral diseases that are common on ornamentals are listed below.

Ash yellows

Plants show reduced growth, stunting and smaller leaves. Symptoms can vary with the age of the plant. In some cases, plants develop chlorotic leaves and witches brooms.

Elm yellows

Leafhoppers probably transmit these mycoplasma-like organisms. Leaves of infected trees begin to turn yellow, twist and droop (epinasty) by mid-summer. The infected leaves often drop and the branch dies shortly after.

Rose mosaic

Rose mosaic symptoms can include leaf discoloration, chlorotic mottling, ringspots, light green or chlorotic line patterns, vein clearing, banding and white or yellow mosaics. Specific symptoms vary with the cultivar, the environment and the strain of virus.

Abiotic Diseases

Abiotic diseases principally affect foliage and/or root system function. These diseases cause many plant problems, often predisposing affected plants to attack by secondary disease organisms. Gradual dieback and mortality may result.

Weather, soil conditions and human environmental disturbances cause these conditions. Control measures depend on eliminating or avoiding damaging factors (e.g. salt injury), obtaining resistant plants and improving growing conditions.

Root scorch from high soil salt levels is a common abiotic condition. It comes from salty irrigation water or from salt applied to remove ice and snow. A late-spring leaf scorch of *Acer* and *Fagus* may come from sudden exposure to full sunlight after a cloudy, wet period.

The ability of a plant to accommodate environmental change varies with the type of plant, its age and condition, and the nature and intensity of the changes. Oak, maple, ash and spruce have difficulty adjusting to new conditions such as soil compaction, drought, excessive water, change in soil level or root damage during construction.

Understanding Dieback

Nursery and landscape ornamentals often exhibit dieback of leaves and small branches. Symptoms may appear on individual branches or entire plants. Dieback may appear suddenly or develop so gradually that the true impact does not show for several years.

Some of the environmental and cultural causes of dieback include girdling wires, strings and ropes left on after transplanting. Root problems, soil conditions, waterlogging, changes in soil grade, sun scald and low temperatures may also be at fault.

Light to moderate infestations of insects and diseases can also cause dieback symptoms. Some examples include scale insects, wood boring insects, bark boring insects, root feeding weevils, white grub larvae, cankers, rusts, fire blight and vascular wilts.

Fall Needle Drop of Conifers

As shorter, cooler autumn days approach, older needles towards the inside of many conifers begin to turn yellow or brown. In some cases, these needles start to drop. This is usually a natural process. The degree of discoloration and leaf drop may relate to stress during the growing season. Low vigour caused by drought, transplanting, poor drainage, soil compaction, insects and disease make needle drop worse.

- Pines lose their oldest needles (closest to the trunk). White pines (*Pinus strobus*) often look quite yellow.
- Small branchlets towards the inside of white cedar (*Thuja occidentalis*) turn brown and fall off.
- Fir (*Abies*) and spruce (*Picea*) may lose needles on 1–3 year-old wood.

Needle Browning on Conifers

Winter damage may cause conifer needles to turn brown and drop in the spring. Many factors can lead to this condition, especially dry, windy weather while the soil is frozen. Roots cannot absorb enough water from the frozen soil to compensate for the foliar desiccation from winter winds.

Good growing conditions during the previous growing season help plants resist winter damage. Roots in the upper soil surface are sensitive to drying and high temperatures. If these roots die during the growing season, poor conditions may prevent sufficient regrowth to recover winter moisture losses.

Salt Damage

Road salt affects woody plants from both runoff and airborne drift. When plant tissues are wet and temperatures are above freezing, sodium and chloride salts (the most common ingredients in road salt) enter plant tissues and accumulate. Repeated road salt injury weakens plants, making them susceptible to damage from many insects and diseases.

Drifting salt spray causes more plant damage than runoff. It can affect plants located 50+ metres away from a road. Symptoms appear more quickly in warm weather and are usually more severe on the side facing the road.

Salt Damage Symptoms on Conifers

- needle browning, beginning at the tip
- needle browning and twig dieback on the side facing the road, while little or none on the opposite side
- no needle browning or dieback on branches near the ground under continuous snow cover
- needle and twig dieback severity decreases as you get further from the road
- browning appears in late February or early March and becomes more obvious through spring and summer

Salt Damage Symptoms on Deciduous Plants

- slow bud break on terminal parts of branches facing the road
- leaves fail to emerge on terminal parts of branches facing the road
- new growth on branches facing the road develops lower, dormant buds that causes a tufted or witches broom appearance
- flower buds on the road side do not open, yet normal flowering occurs on plants further away from the road
- injury becomes evident as buds begin to break

Scorch

Scorch happens when plants have difficulty taking up water, usually during hot, dry weather. It appears as sudden leaf death or browning on leaf margins or between leaf veins, often in August. The veins frequently remain green.

Plants experiencing root injury due to construction, soil compaction, chemicals, drought or extreme heat can show symptoms of scorch.

***Endosulfan* and *Thiodan* are very toxic to fish. Do not apply these products on or near water.**

Using Pesticides

Toxicity Information

The "relative toxicity" of a pesticide is called its LD_{50}. The higher the LD_{50} value of a chemical, the less toxic the product is to humans.

LD_{50} is the chemical's active ingredient (*a.i.*) in mg/kg of test animal body weight that kills 50% of the test animals (usually female rats). LD_{50} is commonly measured as the **Acute Oral LD_{50}**, which means the chemicals are ingested through the mouth or nose. **Dermal LD_{50}** (skin penetration) toxicity values are available on request.

Chemical Families

Most agricultural chemicals belong to a chemical "family," a group of substances that share important characteristics.

The product tables on the next pages list chemical families using abbreviations. The full chemical family names and their associated abbreviations appear here.

TABLE 3–20. Chemical Families

An	aliphatic nitrogenous compound
Arom	aromatic hydrocarbon
Ben	benzimidazole
Dicarb	dicarboximide
Dinitro	dinitrophenol
Dithio	dithiocarbamate
EBI	ergosterol biosynthesis inhibitor
IGR	insect growth regulator
Min	mineral
Morph	morphactin
OC	organochlorine
OP	organophosphorous
Org	organatin
OX	oxithin
Phen	phenylamides
Ph	phthalimide
R	rodenticide
Syn. Pyr.	synthetic pyrethroid
Thia	thiadiazole
Tri	triazole

Pesticide Application Restrictions

It is important to observe restrictions on pesticide application. OMAF recommends only registered agricultural chemicals. However, registration does not mean a product is safe for everyone to use. While some products may be applied by anyone, most are subject to restrictions on use. Restrictions are listed by "schedule number". See Table 3–22, *Pesticide Schedules*, on page 61.

TABLE 3–21. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name)

Product Name	Type	Schedule	Common Name	Oral LD_{50} (mg a.i./kg) **	Chemical Family
Alamo	I	2	propiconazole	2,100	Tri
Ambush	I	3	permethrin	4,000+	Syn. Pyr
APM	I	5	azinphos-methyl	20	OP
Banner	F	2	propiconazole	1,500	Tri
Botran	F	3	dichloran	10,000+	Dicarb
Captan	F	2	captan	9,000	Ph
Clean Crop Copper	F	3	copper sulphate		
Confirm	I	2	tebufenozide	>5,000	Hydra/IGR
Copper 53W	F	3	tribasic copper sulphate		
Copper Spray	F	3	copper oxychloride		
Cygon	I	2	dimethoate	215	OP
Cymbush	I	2	cypermethrin		
Cyprex	F	3	dodine	1,000	AN
Daconil 2787	F	3	chlorothalonil	10,000+	Arom
Danex	I	3	trichlorfon	560	OP
Deadline	M	6	metaldehyde	250	
Diazinon	I	2	diazinon	300	OP
Dipel	I	3	bacillus thuringiensis	non-toxic	Biological
Disyston	I	2	disulfoton	5	OP
Dithane DG	F	3	mancozeb	5,000+	Dithio
Dithane M-45	F	3	mancozeb	6750	Dithio
Dithane Z-78	F	3	zineb	5,000+	Dithio
Dygall	F				
Dylox	I	3	trichlorfon	560	OP
Dyrene	F	3	anilazine	5,000+	Arom
DZN 600	I	2	diazinon	300	OP
Eagle	F	2	myclobutanil	1,600	Tri
Endosulfan	I	2	endosulfan	110	OC
Ferbam	F	3	ferbam	17,000+	Dithio
Folpan	F	3	folpet	10,000	Ph
Foray	I	3	bacillus thuringiensis	non-toxic	Biological
Funginex	F	3	triforine	16,000+	EBI
Ground Force	R		chlorophacinone	2.1	
Guthion	I	5	azinphos-methyl	20	OP
Imidan	I	3	phosmet	300	OP

I = Insecticide; F = Fungicide; R = Rodenticide; A = Acaricide; M = Molluscicide

TABLE 3–21. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name) (Cont'd)

Product Name	Type	Schedule	Common Name	Oral LD_{50} (mg a.i./kg) **	Chemical Family
Karbam Black	F	3	ferbam	17,000+	Dithio
Kelthane	A	2	dicofol	684	OC
Lagon	I	2	dimethoate	215	OP
Lannate	I	2	methomyl	17	Carbamate
Malathion	I	3	malathion	1,400	OP
Manzate 200	F	3	mancozeb	6,750	Dithio
Meltatox	F		dodemorph	4,500	
Metaldehyde bait		3	metaldehyde	630	Metaldehyde
Methoxychlor	I	3	methoxychlor	6,000	OC
Mimic	I	2	tebufenozide	>5,000	Hydra/IGR
Moxy	I	3	methoxychlor	6,000	OC
Nova	F	2	myclobutanil	1,600	Tri
Orthene	I	3	acephate	866	OP
Orthocide	F	2	captan	9,000	Ph
Pentac	A	3	dienochlor	3,160	OC
Phaltan	F	3	folpet	10,000	Ph
Pirimor	I	2	pirimicarb	147	Carbamate
Polyram	F	3	metiram	10,000+	Dithio
Pounce	I	3	permethrin	4,000+	Syn. Pyr
Pyrate	I	3	chlorpyrifos	135	OP
Ramik Brown, Ramik Green	R	3	diaphacinone	3	
Ratak+	R	2	brodifacaum	0.27	
Rodent Bait, Rodent Pellets	R	1,2	zinc phosphide	45	
Rovral	F	3	iprodione	3,550	
Rozol	R		chlorophacinone		
Safers' Insecticidal Soap	I				
Senator 70 WP	F	2	thiophanate methyl	7,500	Ben
Sevin	I	3	carbaryl	560	Carbamate
Slug-Em	M	6	metaldehyde	250	
Sluggo	M	6	ferric phosphate	>5,000	min
Sniper	I	5	azinphos-methyl	20	OP
Stauffer C	F	2	captan	9,000	Ph
Subdue MAXX	F	2	metalaxyl-M and S-isomer	3,436	Phen
Sumithion	I		fenitrothion		
Thiodan	I	2	endosulfan	110	OC
Thionex	I	2	endosulfan	110	OC
Thiram	F	3	thiram	780	Dithio
Thuricide	I	3	bacillus thuringiensis	non-toxic	Biological
Vendex	A	3	fenbutatin oxide	2,631	Organotin
Waxed Mouse Bait	R	1,2	zinc phosphide	45	
Zineb	F	3	zineb	5,000+	Dithio

I = Insecticide; F = Fungicide; R = Rodenticide; A = Acaricide; M = Molluscicide

TABLE 3–22. Pesticide Schedules

Schedule 1	Restricted use by permit only
Schedule 2	Restricted to agriculturists, licensed exterminators and custom sprayers
Schedule 3	May be available for "domestic" purposes if so registered
Schedule 4	"Domestic" products only
Schedule 5	Limited to application on agricultural land
Schedule 6	"Domestic" similar to Schedule 4, but may be registered for agricultural/ commercial use

A Compendium of Pests and Diseases with Recommended Management Practices

Listings appear alphabetically by plant genus. Control products listed appear alphabetically. All listed products are registered for the listed purpose. The order in which products appear does not constitute a preference ranking.

See colour plates at the back of the book for photos of plant pests.

ABIES — fir

	Pest	Control/1000 Litres water	Remarks
INSECTS	Balsam twig aphid (*Mindarus abietinus*)	➢ DZN 600 EW (See product label) ➢ Malathion 500 EC, 1.25 L	Feeds on newly developing needles. Easily identified by its waxy covering. Injured needles are curled and twisted. Treat when aphids first appear (early spring) as bud caps begin to loosen. Wear protective clothing. Apply DZN 600 EW by mist blower at 1.4 L in 50–100 L of water/ha to ensure thorough coverage of trees. Before spraying, spray trees in a half-hectare area with 50 L of water only, to confirm that coverage is adequate.
	June beetle, European chafer (*Phyllophaga* sp., *Rhizotrogus majalis*)		Beetle larvae chew fibrous roots and girdle underground stems of many woody ornamentals (including *Abies* sp.). Till infested fields before planting, to expose grubs to natural predators.
	Spruce budworm (*Choristoneura fumiferana*)	➢ Ambush 500 EC, 35–70 mL ➢ Mimic 240 LV, 290 mL/ha ➢ Foray 48 B, 1.0–2.4 L/ha ➢ Malathion 500 EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Sumithion 50 EC, 0.56L or 0.35 L twice	Black head and brownish body with 4 light spots on the back of each segment. [**Plate 1**] Widespread, important defoliator of balsam fir and spruce, beginning to feed as buds break and continuing until late spring. One generation per year. Apply Mimic to control early instar larvae, allow 3–7 days for larval mortality, a second application may be required. Apply general coverage spray for broad spectrum insecticides in mid-May to control larvae.
	Tarnish plant bug	➢ See under *THUJA*	[**Plate 86**]
DISEASES	Botrytis	➢ See under *THUJA*	
	Canker	➢ See under *CANKERS*	
	Needlecast	➢ Copper spray, 4.0 kg ➢ Daconil 2787 F, 2.5 L	Principally a nursery disease. Caused by several fungi having 2-year life cycles. Symptoms develop early in the second season. Infected needles turn brown and drop. Badly infected plants have only current season needles. Spray after new growth begins and again 10 days later.

ACER — maple

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid	➢ *Endosulfan 50 W, 1 kg ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Malathion 500 EC, 1.25 L ➢ Orthene 76 SP, 1.0 kg ➢ Pyrate 480 EC, 375 mL ➢ Sniper 240 E, 1.75–2.5 L	Treat when adults first appear and repeat as required. Check under leaves for honeydew and sooty mould. Many natural predators (e.g., Ladybugs, hover flies, lacewings). Pesticides will kill predators. *Orthene* may damage sugar maple leaves. **Endosulfan and Thiodan are toxic to fish.*
	Cottony maple scale (*Pulvinaria innumerabilis*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 76 SP, 1.0 kg ➢ Pyrate 480 EC, 2.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Mature female scale resembles a partially popped corn kernel. [**Plate 2**] Attacks maple, linden, elm, beech, oak and other trees and shrubs. Found only on twigs. Use Superior oil or Ethion superior oil as early-spring dormant treatment, *except* on sugar and Japanese maples. Nymphs active first week of July, about when *Philadelphus* and *Tilia cordata* bloom. Cover lower leaf surface with spray. Apply again 10 days later. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.

ACER — maple (cont'd)

	Pest	Control/1000 Litres water	Remarks
INSECTS	Forest tent caterpillar (*Malacosoma disstria*)	➢ Ambush 500 EC, 70 mL ➢ Dipel 132 ES, 0.5–1.0 L/ha ➢ Foray 48B, 1.0–1.6 L/ha ➢ Orthene 76 SP, 1.0 kg ➢ Pyrate 480 EC, 500 mL ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Thuricide, 1.5–2.0 L	Does not form a tent. May completely defoliate broadleaf trees, particularly poplars, over a wide area. Has series of "key-hole" shaped white spots along its back. Present early in the season. Feeds in colonies. [**Plate 3**] Treat foliage mid- to late May to control larvae. *Orthene* may damage sugar maple leaves.
	Greenstriped mapleworm (*Dryocampa rubicunda*)	➢ Sevin 50 W, 2.0–3.0 kg	Cherry red head and yellowish body with seven dark lines running its entire length. Preferred hosts are maple, oak and box elder. Usually does not require control. Eggs hatch over an extended period. If necessary, spray from mid-June to late July.
	Gypsy moth	➢ See under *BETULA*	[**Plate 13 & 14**]
	Japanese beetle	➢ See under *ROSA*	[**Plate 74 & 75**]
	Leafhopper	➢ See under *MALUS*	
	Lecanium or European fruit lecanium (*Lecanium corni*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 76 SP, 1.0 kg ➢ Pyrate 480 EC, 2.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	A large, reddish-brown, spherical scale usually found on the underside of twigs. [**Plate 4**] Infests many deciduous trees and shrubs. Use Superior oil or Ethion superior oil as early-spring dormant treatment. Spray any of the other materials when the *Sambucus canadensis* begins blooming to suppress crawlers. Do not use Malathion on Crimson King maple. Orthene may damage sugar maple leaves.
	Crimson erineum mite (*Eriophyes regulus*) Maple bladder gall mite (*Vasates quadripedes*) Maple spindle gall mite (*Vasates aceriscrumena*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 2.5 L ➢ Superior oil, 20 L	Crimson erineum mite causes granular red, velvety patches on both sides of sugar, silver and red maple leaves. Maple bladder gall mite causes globular, wart-like galls on the upper surface of silver and red maple leaves. Heavy infestations may completely deform leaves but seldom injure trees seriously. Maple spindle gall mite produces 5 mm long, slender fusiform galls on the upper surface of sugar and silver maple leaves. Several generations per year. Use Superior oil or Ethion superior oil as an early-spring dormant treatment. Do not use oil on sugar and Japanese maples. Apply Malathion in spring when temperature is 2°C or higher. Do not use Malathion on Crimson King maple.
	Maple petiole borer (*Caulocampis acericaulis*)	Tunnels in maple leaf stems, causing leaves to break near the blade and fall. To reduce borer populations, collect and destroy infested fallen leaf stems before the larvae leave them.	
	Maple trumpet skeletonizer (*Epinotia aceriella*)	➢ Methoxychlor 240 EC, 4.0 L ➢ Sevin 50 W, 2.0–3.0 kg	Normally a minor problem, it attacks sugar, red and silver maples. Spins a long trumpet-like tube of silk and frass on the underside of a leaf, which folds around it. Feeds from within this tube, skeletonizing the part of the leaf covered by the web. [**Plate 5**] This causes the leaf to crumple. May attack hawthorn and beech. Larvae exist from late July to September. Apply control to bottom leaf surfaces from mid-July to mid-August.
	Sugar maple borer (*Glycobius speciosus*)	Usually a landscape problem, especially on stressed trees. A robust, black, longhorned beetle with five yellow bands on the wing covers. The fleshy white larva cuts deep channels in the wood. Cracked, swollen areas resembling cankers indicate infestation. Has a 2-year life cycle. Females cut a slit into the bark and lay eggs in late July and into August. Keep trees vigorous.	
	Whitemarked Tussock moth (*Orgyia leucostigma*)	➢ Mimic 240 LV, 290 mL/ha	A large caterpillar (up to 3 cm long) with a multicolour body marked by [illegible] tufts of black hairs behind the head and white hairs along the sides of the abdomen. Caterpillars are found throughout the growing season on many species of deciduous and evergreen trees. Apply Mimic to control early instar larvae, allow 3–7 days for larval mortality. A second application of Mimic may be required.

ACER — maple (cont'd)

	Pest	Control/1000 Litres water	Remarks
DISEASES	Anthracnose	➣ Banner 130 EC, 340 mL	Leaves are infected as they emerge in the spring. Causes irregular brown lesions, often in between veins. Leaves may be distorted. Apply Banner every 14 days, as buds break and leaves unfold in the spring. Do not exceed more than 4 applications of Banner per year. To avoid chemical resistance, rotate Banner with fungicides from other chemical families. Collect and destroy fallen leaves in autumn, as they are a source of inoculum the following spring.
	Canker	➣ See under *CANKERS*	
	Dieback	➣ See *ABIOTIC DISEASES*	
	Leaf scorch	➣ See *ABIOTIC DISEASES*	[**Plate 73**]
	Leaf spot	➣ See under *CATALPA*	
	Tarspot *(Rhystima acerinum,* *R. punctatum)*	Leaves infected in spring during cool, wet weather. Causes irregular black tar-like spots on Norway, red, silver and sugar maple leaves by mid- to late summer. [**Plate 6**] Improve air circulation to encourage quick leaf drying. Disease overwinters on fallen leaves — rake and discard leaves in autumn.	
	Verticillium wilt	Infection causes sapwood to darken. [**Plate 7**] Prune wilted branches back to healthy wood. Thin remainder of crown. Fertilize and water to promote vigour, especially root growth. Disease often followed by frost cracks and associated cankers. See *Susceptible and Tolerant Plants*, page 56.	

AESCULUS — horsechestnut

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Leaf scorch	➣ See *ABIOTIC DISEASES*	
	Anthracnose (*Glomerella cingulata*)	➣ Daconil 2787 F, 2.5 L	Leaves infected during cool, wet springs. Encourage good air circulation through the canopy. Do not crowd plants.
	Leaf blotch (*Guignardia aesculi*) (*Botryosphaeria acesculi*)	➣ Daconil 2787 F, 2.5 L	Large blotchy, reddish-brown lesions surrounded by a yellow halo. [**Plate 8**] Appears on leaves by mid-summer. Leaves often curl and distort. A tree may show symptoms of leaf blotch, scorch and anthracnose. Leaves infected during cool, wet springs. Encourage good air circulation through the canopy. Do not crowd plants.

AMELANCHIER — serviceberry

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Cedar-apple rust (*Gymnosporangium* sp.)	➣ Nova 40 W, 250–340 g	Treat when sporulation begins on alternate host (*Juniperus*), in mid-spring. Spores from Juniperus hosts can infect Rosaceous plants (*Malus, Crataegus, Amelanchier*, etc.). Repeat fungicidal application every 10–14 days if needed. Rotate Nova with registered fungicides of other chemical families to avoid resistance.

BETULA — birch

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid (*Calaphis betulaecolens*) (*Euceraphis punctipennis*) (*Hamamelistes spinosus*)	➢ Cygon 480 E, 625 mL ➢ See under FAGUS	*Calaphis betulaecolens*, a large green aphid, feeds only on birch. *Euceraphis punctipennis*, a black and green aphid, leaves a cottony-white wax on birch and alder. *Hamamelistes spinosus* also affects *Hamamelis* (witch hazel). Feeding nymphs cause corrugated swellings between veins on leaves. Treat when adults first appear; repeat as required. Check underside of leaves for honeydew and sooty mould. Many natural predators (e.g., ladybugs, hover flies, lacewings). Pesticides will kill predators.
	Birch leaf miner (*Fenusa pusilla* and many other species)	➢ Cygon 480 E, 500 mL ➢ DZN 600 EW, 830 mL ➢ Di-syston, 15% granules (see product label) ➢ Lagon 480, 500 mL ➢ Malathion 500 EC, 2.5 L ➢ Orthene 76 SP, 1.0 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	Forms a blotch mine covering half or more of each leaf. [**Plate 9**] Foliage of heavily infested trees looks scorched. Two generations a year, second flush of growth is also attacked. Adult, a small black sawfly, emerges from soil when first birch leaves are half grown. First mines appear when *Spiraea x vanhouttei* blooms. When mines appear, use any listed control in mid-May and again in late June. Use Cygon after mines appear. Use Cygon 2E as a soil drench or "brush-on" treatment.
	Birch skeletonizer (*Bucculatrix canadensisella*)	➢ Sevin 50 W, 2.0–3.0 kg	Generally not a problem. Small yellowish-green larvae attack birches and some alders. Feeds on the bottom of leaves from mid- to late summer. Collect and destroy fallen leaves to remove overwintering pupae. Thoroughly spray underside of leaves about mid-August.
	Bronze birch borer (*Agrilus anxius*)	➢ Pyrate 480 EC, 500 mL	Attacks injured and weakened birch trees. The elongated white larvae make long, winding tunnels just under the bark. Tunnels show up as spiral ridges around the branches and trunk. [**Plate 10**] Larvae develop over 2 years and emerge as adults from June to August, through a D-shaped hole. [**Plate 11**] Adult is a slender, olive-bronze beetle. Remove and destroy weakened and dying branches before mid-May. Good tree health reduces infestation risks. Birch roots do not compete well with lawn grasses. Deeply water the root zone several times during the growing season. Control birch leaf miners to reduce stress. Direct spray at trunk and branches. Chemical control is very difficult.
	Gypsy moth (*Lymantria dispar*)	➢ Dipel 132 ES, 1.6–2.4 L/ha ➢ Foray 48 B, 1.0–1.6 L/ha ➢ Orthene 75 SP, 850 g ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Thuricide HPC, 1.6 L	Dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. [**Plate 13**] They feed in the spring and early summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs, but prefer basswood, birch, hawthorn, oak, poplar and willow. Females lay eggs in brown fuzzy masses July and August. [**Plate 14**] Remove and destroy egg masses before they hatch. Egg masses on the north side hatch later than those on the south side. Apply treatments about 3 weeks after hatching, when *Spiraea x vanhouttei* are in bloom. Treat larvae as feeding begins. A folded burlap cloth wrapped around a tree provides a daytime shelter for larvae or pupae. Collect them from these shelters and destroy them.
	Japanese beetle	➢ See under *ROSA*	

BUXUS — boxwood

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Boxwood leafminers (*Monarthropalpus buxi, M. flavus*)	➢ Cygon 480 E, 1 L ➢ DZN 600 EW, 830 mL ➢ Diazinon 500 EC, 1 L ➢ Lagon 480, 1 L ➢ Malathion 50, 1.5 L ➢ Sevin 50 W, 2.0–3.0 kg	The adult is a gnat-like fly. Larvae overwinter in leaves. Leaves are mined during the summer. Treat in June when first mines begin to appear.
	Boxwood psyllid (*Psylla buxi*)	➢ Sevin 50W, 2.0–3.0 kg	Young nymphs feed on developing leaves. Leaves become cupped, enclosing the nymphs. Overwintering eggs hatch as buds begin to break in spring. Treat young psyllids in early May.
DISEASES	Canker (*Volutella buxi*)	Purplish black cankers appear on stems and leaves of *Buxus* sp [**Plate 12**]. Can be a problem in propagation areas. Always inspect cuttings and rooting beds for signs of canker. Higher temperatures and well-drained media will accelerate rooting and decrease incidence of this disease in propagation (e.g. summer propagation). Remove and destroy infected leaves and stems in established plants.	

CARYA — hickory

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Hickory gall adelgid (*Phylloxera caryaecaulis*)	➢ Malathion 500 EC, 1.25 L ➢ Pyrate 480 EC, 375 mL	Produces nearly round galls on hickory twigs and leaf stems. Galls are about 16 mm in diameter. Girdled twigs die and break at the location of a gall. Overwintering eggs hatch as buds break. Apply controls at that time. Treatment is ineffective once galls appear. Infestations will not kill the tree.
	Walnut caterpillar	➢ See under *JUGLANS*	
	Lacebug	➢ See under *FRAXINUS*	
DISEASES	Leaf spot	➢ See under *CATALPA*	

CATALPA — catalpa

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Leaf spot	Usually not necessary to spray. Destroy or compost fallen leaves.	

CHAENOMELES — quince

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Fire blight	➢ See under *MALUS*	[**Plate 42**]

CORNUS — dogwood

	Pest	Control/1000 Litres Water	Remarks
INSECTS	June beetle, European chafer (*Phyllophaga* sp., *Rhizotrogus majalis*)	➣ Sevin XLR PLUS, 2.3–3.5 L	Beetle larvae chew fibrous roots and girdle underground stems of many woody ornamentals (including *Cornus* sp.). [**Plate 17**]. Till infested fields before planting, to expose grubs to natural predators. Sevin XLR PLUS is registered as a foliar spray for adults.
DISEASES	Anthracnose	➣ Banner 130 EC, 340 mL	Leaves develop brown lesions in spring, often between veins. Leaves may become deformed and drop off. This fungus infects leaves as they are emerging in the spring. Apply Banner every 14 days as buds break and leave unfold. Do not exceed a maximum of 4 applications per year. To avoid resistance, rotate Banner with registered fungicides of other chemical families where possible.
	Twig blight	Caused by several different fungi. Cankers appear at the base of dead twigs. Prune infected twigs and branches back to healthy wood. Improve cultural conditions by watering during drought and fertilizing. Do not crowd plants — maintain adequate sunlight and good air circulation.	
	Leaf spot	➣ Daconil 2787 F, 2.5 L	Caused by several different fungi. [**Plate 18**] Avoid overhead irrigation late in the day. Do not crowd plants — maintain adequate sunlight and good air circulation.

COTONEASTER — cotoneaster

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Phytophthora root rot	Roots become water-soaked and turn brown, stems and leaves turn brown and die, diseased leaves often persist on stems [**Plate 19**]. Often associated with overwatering or low aeration porosity of media.	

CRATAEAGUS — hawthorn

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Eastern tent caterpillar	➣ See under *MALUS* ➣ Orthene 75 WP, 1.0 kg	[**Plate 40**]
	Gypsy moth	➣ See under *BETULA*	[**Plate 13 and 14**]
	Hawthorn leafminer (*Profensua canadensis*)	➣ Malathion 500 EC, 2.5 L ➣ Sevin 50 W, 2.0–3.0 kg	Forms a blotch mine covering half or more of each leaf. Foliage of heavily infested trees looks scorched. Adult is a small, black sawfly that emerges from the soil as the first leaves start to emerge and blossoms begin to open. Adults active as leaves begin to unfold. Treat foliage undersides in mid-spring and late spring to control larvae.
DISEASES	Leaf blight (*Diplocarpon* sp).	➣ Dithane M-45 80 WP, 2.75–3.5 kg	Causes small brown spots on leaves in mid-summer. Spray in spring as leaves emerge. Do not crowd plants — maintain adequate sunlight and good air circulation. Avoid summer pruning, which encourages susceptible soft growth.
	Hawthorn rust (*Gymnosporangium globosum*)	➣ Daconil 2787 F, 2.5 L	Orange spots on leaf surfaces in late spring. Finger-like structures appear on leaf undersides by mid- to late summer (*G. globosum*). [**Plate 15**] Infections of *G. clavipes* also appear on fruit and stems. [**Plate 16**] Apply fungicide before bloom. Remove alternate juniper hosts. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Quince rust (*G. clavipes*)		

CRATAEAGUS — hawthorn (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Leaf spot (*Fabraea* sp).	➢ Daconil 2787 F, 2.5 L	Slightly depressed, angular, reddish-brown spots which join together. By mid-summer, dead areas have dark raised bumps (fruiting structures). Collect and destroy fallen leaves. Spray as flower buds open. Repeat if spots develop 10 and 20 days later. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Scab	➢ See under *MALUS*	[**Plate 43**]
	Fire blight	➢ See under *MALUS*	[**Plate 42**]

EUONYMUS — euonymus

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil	➢ See under *TAXUS*	[**Plate 80 & 81**]
	Euonymus scale (*Unaspis euonymi*)	➢ [1]APM 50 W, 1.0–1.25 kg ➢ [1]Guthion 240 SC, 1.75–2.5 L ➢ [1]Guthion 50 WP, 0.925–1.25 kg ➢ [1]Sniper 50 W, 0.925–1.25 kg ➢ Cygon 480 E, 2 L ➢ Ethion superior oil, 20 L ➢ Orthene 75 SP, 1.0 kg ➢ Superior oil, 20 L	This greyish, pear-shaped scale affects bittersweet (*Celastrus*) and *Pachysandra*. [**Plate 20 & 21**] It produces 2 generations a year, the 2nd generation appears about 6 weeks after the first. Examine plants during the dormant season, prune out highly infested regions and use dormant oil. Apply insecticides as nymphs emerge. *Catalpa speciosa* are beginning to bloom at this time, *Kolkwitzia* and *Philadelphus* are also blooming. Repeat treatment after 7 days. [1] *Minimum re-entry period is 48 hr.*
	Euonymus webworm (*Yponomeuta cagnagella*)	A pale green caterpillar with black spots along each side. Feeds on leaves in localized, webbed colonies. [**Plate 22**] Severe defoliation can occur during June. Monitor deciduous euonymus for webbed colonies in May and June. Where possible, prune colonies out and destroy.	
DISEASES	Anthracnose (*Glomerella cingulata, Colletotrichum gloeosporioides*)	➢ Daconil 2787, 2.5 L	Leaf spotting, leaf drop and twig dieback may occur. [**Plate 23**] To protect new growth, spray at spring bud break, especially on plants in overwintering houses. Do not crowd plants — maintain adequate sunlight and good air circulation. Avoid overhead irrigation late in the day. Prune out dead and dying twigs.
	Crown gall (*Agrobacterium tumefaciens*)	➢ Dygall, 160 g/50 L	Large abnormal growths on stems and roots. [**Plate 24**] Susceptible plants must be treated before disease exposure or final field placement. Do not wound or damage the plants. Remove and destroy infected plants.

FAGUS — beech

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid Beech blight aphid (*Fagiphagus imbricator, Grylloprociphilus imbricator*) Woolly beech leaf aphid (*Phyllaphis fagi*)	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ [1]APM 50 W, 1.0–1.25 kg ➢ [1]Guthion 50 WP, 0.925–1.25 kg ➢ Pyrate 480 EC, 375 mL ➢ Malathion 500 EC, 1.25 L ➢ Orthene 76 SP, 1.0 kg ➢ [1]Sniper 50 W, 0.925–1.25 kg	Conspicuous white, cottony threads cover beech blight aphid and woolly beech leaf aphid. Beech blight aphid appears on twigs and small branches. The woolly beech leaf aphid feeds on leaf undersides. While unsightly, they cause little tree damage unless very high populations exist. Treat when aphids first appear and repeat as needed. Excessive fertilization or pruning can cause undesirable succulent growth levels. * *Endosulfan and Thiodan are toxic to fish.* [1] *Minimum re-entry period is 48 hr.*
	Cankerworm	➢ See under *MALUS* ➢ Orthene 76 SP, 1.0 kg	[**Plate 38 & 39**]
	Gypsy moth	➢ See under *BETULA*	[**Plate 13 & 14**]

FORSYTHIA — forsythia

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Bacterial blight (*Pseudomonas syringae*)	➣ Clean Crop Copper Spray, 6.0 kg	Young shoots or leaves turn black between early spring and early summer, especially during wet, cool weather. Apply once in October, and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Do not crowd plants — maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.

FRAXINUS — ash

	Pest	ControL/1000 Litres Water	Remarks
INSECTS	Ash flower gall mite (*Eriophyes fraxiniflora*)	➣ Ethion superior oil, 20 L ➣ Malathion 25 WP, 2.0 kg ➣ Superior oil, 20 L	Becomes active as ash male flower buds break in the spring. Feeds on the unfolding tissues, causing them to form irregular gall clusters of 12 mm diameter. Use Superior oil or Ethion superior oil as a dormant treatment. Mites become active as flower buds break in the spring. Use Malathion when first blossoms begin to form.
	Ash borer (*Podosesia syringae*)	➣ *Endosulfan 400, 1.25 L ➣ *Thiodan 4 EC, 1.25 L ➣ Pyrate 480 EC, 500 mL	Adults are dark brown, wasp-like moths, present from late May to late July (during *Syringa vulgaris* bloom). Larvae bore into trunks near the base. Lilac, mountain ash and privet are also hosts. Cut and destroy infested wood before May. Stressed trees are more susceptible to borers. Prevent wood and bark damage. Remove badly infested trees. Use pheromone traps. Treat trunk and large branches, especially around wounds. Repeat twice at 10-day intervals. Begin applications about 10 days after peak catch numbers. * *Endosulfan and Thiodan are toxic to fish.*
	Ash plant bug (*Tropidosteptes amoenus*)	➣ Dylox 420, 2.75–4.0 L ➣ Sevin 80 S, 1.25–2.0 kg	Feeds on *Fraxinus americana* and *F. pennsylvanica*. Young nymphs feed on leaf bottoms, causing leaf stippling. To monitor for plant bugs, tap a branch over a sheet of white paper or tapping tray.
	Emerald ash borer (*Agrilus planipennis*)	This is an introduced insect first found in Essex county, Ontario in 2002. Larvae bore into the cambium, making winding/serpentine tunnels just under the bark [**Plate 25**]. Small (8–14 mm), metallic green, adult beetles emerge through D-shaped holes in bark from spring to summer. The larval tunnels kill off sections of the tree, leading to dieback, epicormic branching at the base and tree mortality. Most common on *Fraxinus pennsylvanica*. This is a quarantined pest, regulated by the Canadian Food Inspection Agency.	
	Fall webworm (*Hyphantria cunea*)	➣ Dipel 132 ES, 0.7–1.7 L/ha ➣ Orthene 75 SP, 1.0 kg	Large webs appear in August, over branch ends of ash, box-elder, flowering crab and many shade trees. [**Plate 26**] The very hairy caterpillar is pale yellowish green. Chemical control rarely needed. Remove webs and caterpillars by hand and destroy.
	Gypsy moth	➣ See under *BETULA*	[**Plate 13 & 14**]
	Sycamore lacebug (*Corythucha ciliata*)	➣ [1]APM 50 W, 1.0–1.25 kg ➣ [1]Guthion 50WP, 0.925–1.25 kg ➣ [1]Sniper 50 W, 0.925–1.25 kg ➣ Malathion 500 EC, 1.25 L ➣ Orthene 75 SP, 1.0 kg ➣ Sevin XLR PLUS, 2.3–3.5 L	Flat, rectangular insects, 4–6 mm long with broad, transparent, lacelike wing covers. Adults and nymphs feed on underside of leaves. Leaves become pale and mottled, with white splotches. Lower leaf surfaces develop black and brownish dots. Heavily infested leaves may turn entirely brown and fall off. Most species have 2 generations a year. Lacebugs usually occur on a single host. Other trees commonly attacked include elm, hickory, linden, oak and walnut. Apply to leaf bottoms when insects first appear. [1] *Minimum re-entry period is 48 hr.*
	Lecanium scale	➣ See under *ACER*	

FRAXINUS — ash (cont'd)

	Pest	ControL/1000 Litres Water	Remarks
	Leopard moth (*Zeuzera pyrina*)		The larval stage bores into the branch tips and eventually into heartwood of trees (as it grows larger), weakening the tree and causing dieback and tree mortality. Look for bore holes in branch tips and large bore holes with sawdust at the base of the trunk [**Plate 27**]. Larvae are large (up to 50 mm), crème-coloured with black spots [**Plate 28**]. Control is difficult once the borer has become established in a tree. Remove infested trees and destroy. Insert a piece of flexible wire in the bore hole to destroy larvae where possible. Leopard moths are rarely found in large numbers. Most recently, this pest has been found on green ash trees in the Niagara region.
	Oystershell scale (*Lepidosaphes ulmi*)	➢ Diazinon 500 EC, 1.5 L ➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 2 L ➢ Superior oil, 20 L	Attacks over 125 forest, shade, fruit and ornamental tree species. In heavy infestations, greyish scales completely encrust twigs and stems. This can cause branch and tree mortality. Mature females are 3 mm long and rounded at the rear. Use Superior oil or Ethion superior oil as a dormant treatment. Use any of other materials against crawlers in late May. Apply again 10 days later, about the time *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches and leaf bottoms.
DISEASES	Anthracnose (*Gloeosporium aridum*)	➢ Dithane M-45, 80 WP, 2.75–3.5 kg ➢ Manzate 200 DF, 2.75–3.50	Causes leaf spots, marginal leaf browning and leaf deformation. [**Plate 29**] Defoliation may occur in late spring and early summer. Apply at 10–14 day intervals, beginning before bud burst and continuing while wet weather persists in spring. Collect and destroy fallen leaves. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Dieback	➢ See *ABIOTIC DISEASES*	
	Leaf spot, (*Mycosphaerella* sp).	➢ Daconil 2787 F, 2.5 L	Brown spots with yellowish borders appear by late summer. Apply at bud break. Collect and destroy fallen leaves. Do not crowd plants — maintain adequate sunlight and good air circulation.

GLEDITSIA — honey locust

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cottony maple scale	➢ See under *ACER*	[**Plate 2**]
	Leafroller	➢ See under *MALUS*	
	Honeylocust spider mite (*Eotetranychus multidigituli*)	➢ [1]Guthion 50 WP, 0.925–1.25 kg ➢ [1]Sniper 50 W, 0.925–1.25 kg ➢ Kelthane EC, 1.25–2.50 L ➢ Orthene 75 SP, 1.0 kg	Adults overwinter on bark. Feeding causes stippling, bronzing and discoloured foliage. [**Plate 30**] Heavy infestation may cause defoliation. Treat when mites appear and again in 10 days. Repeat procedure as needed. [1] *Minimum re-entry period is 48 hr.*
	Honeylocust plant bug (*Diaphnocoris chlorionis*)	➢ Dylox 420, 2.75–4.0 L ➢ Sevin 80 S, 1.25–2.0 kg	Plant bugs become active as new leaves begin to develop. They cause leaf yellowing, stippling, stunting and deforming early in the season. [**Plate 30**] Shoot dieback may occur. To monitor for plant bugs, tap a branch over a sheet of paper or tapping tray or use a sweep net.
	Honeylocust podgall midge (*Dasyneura gleditchiae*)		The adult is a small fruit fly-like insect. It lays eggs on new leaflets and larvae feed on the inner surface. This causes a pod-like structure to appear. There are several generations a year. Chemical control is very difficult.
	Leafhopper (*Macropsis fumipennis*)	➢ [1]APM 50 W, 1.0–2.5 kg ➢ [1]Guthion 50 WP, 0.925–1.25 kg ➢ [1]Sniper 50 W, 0.925–1.25 kg ➢ Methoxychlor 240 EC, 4.0 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 1.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L	Symptoms include leaf spotting and stippling. [**Plate 30**] Leafhoppers become active as new leaves begin to develop. Treat leaf bottoms when leafhoppers are active (about mid-June) and repeat as needed. To monitor leafhoppers, tap a branch over a sheet of paper or tapping tray or use a sweep net. [1] *Minimum re-entry period is 48 hr.*
	Lecanium scale	➢ See under *ACER*	
	Rust mite	➢ Kelthane 187.5 EC, 1.25 L	Heavy infestations may cause foliage bronzing. Apply to both leaf surfaces when mites are active (about mid-June) and repeat as needed.
	Thrips	➢ See under *LIGUSTRUM*	

HYDRANGEA — hydrangea

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Botrytis blight	➣ Botran 75 W, 1.75 kg	Infected plant parts develop a fuzzy grey growth under very high humidity. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Do not crowd plants — maintain adequate sunlight and good air circulation.

JUGLANS — butternut, walnut

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Walnut blister mite (Eriophyes *erinea*, *Aceria erinea*)	➣ Kelthane 187.5 EC, 2.5 L	Feeds on walnut and butternut leaves, causing yellow or brown felt-like galls. Overwintering mites become active as new spring growth begins. Apply to lower surface of newly-formed leaves.
	Walnut caterpillar (*Datana integerrima*)	➣ Malathion 500 EC, 2.5 L ➣ Methoxychlor 240 EC, 4.0 L ➣ Sevin 50 W, 2.0–3.0 kg	Larvae are black with long gray hairs. Feeds on walnut and hickory. Caterpillar colonies descend tree trunks and molt, leaving a conspicuous clump of gray cast skins on the trunk. Adult moths lay eggs in early July and larvae feed until the end of August. Spray when larvae first appear, usually in July. Feeding will continue into August and September. Spray or remove larvae clustering on trunk.
DISEASES	Butternut canker (*Sirococcus clavigignenti juglandacearum*)	Dark brown-black cankers on branches and/or stems. Cankers are sunken, elongated and diamond-shaped. Dying branches in the crown. Older cankers may show successive rings of callus loosely covered with bark. During spring, thin black fluid oozes from cracks in the bark and deposits a dried, sooty black stain. No known treatment.	

JUNIPERUS — juniper

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Juniper midge (*Contarinia juniperina*)	➣ Cygon 480 E, 2.5 L	A problem on eastern red cedar, *Juniperus virginiana*. Tips of injured plant shoots turn brown during June and July due to midge larvae feeding from the previous summer. No serious damage. Adults active from late May to July. If needed, treat the foliage at 2–3 week intervals beginning in late June.
	Juniper scale (*Carulaspis juniperi*)	➣ DZN 600 EW, 1.25 L ➣ Diazinon 500 EC, 1.5 L ➣ Malathion 500 EC, 2.5 L ➣ Sevin XLR PLUS, 2.3–3.5 L	A small, circular, white scale with a yellow centre. [**Plate 31**] Turns juniper and arborvitae needles yellow. Attacks all juniper species, including Pfitzer and Savin. Sooty mould fungus sometimes develops. Treat crawlers about late June and repeat as needed, starting when *Philadelphus* is at full bloom and *Catalpa* are beginning to bloom. Do not use Malathion on Savin or Canaetri junipers.
	Juniper tip gall midge (*Rhopalicus* sp, *Oligotrophus betheli*)	Galls on shoot ends caused by larvae feeding. The adult is a chalcid wasp.	
	Juniper webworm (*Dichomeris marginella*)	➣ Cygon 480 E, 2.5 L ➣ Lagon 480, 2.5 L ➣ Sevin 50 W, 2.0–3.0 kg	A light brown caterpillar, about 12 mm long, that feeds at the base of needles. Needles are webbed together during early fall and again the following spring. Treat foliage when larvae are active (late August and September).
	Spruce spider mite	➣ Morsetan 0.625–1.25 kg ➣ See under *PICEA*	
	Tarnish plant bug	➣ See under *THUJA*	[**Plate 86**]

JUNIPERUS — juniper (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Cedarapple rust (*Gymnosporangium juniperi-virginianae*) Hawthorn rust (*G. globosum*) Quince rust (*G. clavipes*)	➢ Eagle WSP, 300 g (1 pouch in 280 L of water)	Cedarapple and hawthorn rust cause slimy, orange galls on juniper twigs in mid-spring. When dormant, cedarapple rust galls [**Plate 32**] and hawthorn rust galls [**Plate 33**] can be located in juniper foliage by their orange horns. Quince rust causes cankers in the twigs. Starting in mid-summer, apply Eagle every 10–14 days when infected alternate Rosaceous hosts (*Malus,Crataegus, Amelanchier*, etc.) are sporulating. To avoid resistance, rotate Eagle with registered fungicides from other chemical families where possible. Eagle can also be tank-mixed with Dithane. Prune out dormant galls and cankers on infected branches before May. Separate Rosaceous rust hosts from Junipers. Plant resistant junipers where possible
	Blight (dieback) (*Phomopsis juniperovora)* or (*Kabatina juniperi*)	➢ Copper Spray, 4.0 kg ➢ Dithane M-45, 80 WP, 2.75–3.5 kg	Causes dieback of new shoots. [**Plate 34**] Stressed plants and wounded shoots are more susceptible. Avoid overhead irrigation late in the day. Do not crowd plants — maintain adequate sunlight and good air circulation. If possible, prune out infected areas. Maintain healthy growth, but do not encourage soft, succulent growth through excessive pruning and over fertilization. Spray when spring growth starts. Repeat at 10 day intervals until growth stops. Laboratory diagnosis is needed to distinguish between *Kabatina* and *Phomopsis*.

LARIX — larch

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Larch casebearer (*Coleophora laricella*)	➢ Malathion 500 EC, 2.5 L	Larvae feed in needles until late summer. Mined needles make the tree appear frost damaged. Treat in early May.
	Larch sawfly (*Pristiphora erichsonii*)	➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Orthene 75 SP, 1.0 kg ➢ Sevin 50 W, 2.0–3.0 kg ➢ Sevin 80 S, 1.25–2.0 kg	Larvae are grey with black heads, 20 mm long. Active mid- to late summer. Monitor for shepherd's crooks, caused by egg laying, in the new growth. Treat foliage in July when larvae are half-grown.
	Tarnish plant bug	➢ See under *THUJA*	[**Plate 86**]
	Woolly larch adelgid (*Adelges laricis*)	➢ Malathion 500EC, 1.25 L	Adelgids feed on needles and are covered by waxy, woolly, cottony threads. Heavy infestations look like snow. Damaged leaves become bent or twisted. Treat foliage thoroughly when aphids first appear (about early May).

LIGUSTRUM — privet

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Lilac leafminer	➢ See under *SYRINGA*	Treat both leaf surfaces when mites first appear in late May. Repeat as required.
	Privet rust mite (*Aculus ligustri*)	➢ Kelthane 187.5 EC, 2.5 L	Mites become active as new leaves emerge, from May to November. Damage appears as leaf russetting. Treat when mites first appear. Repeat as needed. Encouraged by cooler weather.
	Privet Thrips (*Dendrothrips ornatus*)	➢ [1]Guthion 50 WP, 0.925–1.25 kg ➢ [1]Sniper 50 W, 0.925–1.25 kg ➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 500 mL ➢ Sevin XLR PLUS, 2.3–3.5 L	Treat at first sign of infestation and repeat as needed. Injury appears as yellowish flecks on leaves. Leaves look greyish or dusty. [1] *Minimum re-entry period is 48 hr.*
DISEASES	Anthracnose and twig blight (*Glomerella* sp.)	➢ No chemical control	Leaves turn brown and remain attached to twigs. Prune and destroy infected branches during dry weather. *Ligustrum amurense*, *L. x ibolium* and *L. obtusifolium regelianum* do not appear susceptible.
	Leaf spot (Several fungi)	➢ Daconil 2787 F, 2.5 L	Brown spots appear on leaves, especially after wet springs. Treat plants during prolonged wet conditions. Do not crowd plants — maintain adequate sunlight and good air circulation.

LIRIODENDRON — tuliptree

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Tuliptree aphid (*Macrosiphum liriodendri*)	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Malathion 500 EC, 1.25 L	A green aphid found on underside of leaves from late June to late September. Treat when aphids first appear and repeat as needed. Excessive fertilization or pruning can cause excessive, susceptible succulent growth. * *Endosulfan and Thiodan are toxic to fish.*
	Tuliptree scale (*Toumeyella liriodendri*)	➢ Malathion 500 EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Dark brown, hemispherical scale attacks several deciduous tree species. Use Superior oil as a dormant treatment in early spring. Use any of the other materials when crawlers appear in August.

LONICERA — honeysuckle

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Honeysuckle aphid (*Hyadaphis tataricae*)	➢ Malathion 500 EC, 1.25 L ➢ Pirimor 50 WP, 500 g	Causes early season curling and dwarfing of terminal shoots. Affected branch portion may be several centimetres long. Affected stems eventually die, causing a witches' broom. May completely disfigure heavily affected bushes. Dead shoots visible the following spring. Prune out witches' brooms from the previous season before buds begin to break in the spring. Apply dormant oils after pruning to control overwintering eggs. Apply treatment when buds begin to break. Repeat at least once after a 3-week interval. Susceptible varieties include: *Lonicera x bella* 'Dropmore,' *L. korolkowii* 'Zabelli,' *L. tatarica* 'Grandiflora,' 'Rosea,' 'Hack's Red,' and 'Red Giant.'
DISEASE	Honeysuckle blight (*Herpobasidium deformans*)	➢ Dithane DG, 2 kg	Not a common disease in most of Ontario. Many species are susceptible. Symptoms appear as new leaves expand in spring. Infected leaves are curled and turn brown. The veins tend to remain green at first. Spray chemical when leaf buds show green tip to half-inch green leaf. Repeat application in 10–14 day intervals. Avoid overhead irrigation late in the day. Remove and destroy infected leaf material to reduce inoculum the following spray.

MAGNOLIA — magnolia

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Magnolia scale (*Neolecanium cornuparvum*)	➣ Malathion 500 EC, 2.5 L ➣ Orthene 75 WP, 1.75 kg ➣ Sevin XLR PLUS, 2.3–3.5 L ➣ Superior oil, 20 L	Mature scale is large (up to 1 cm) and pink-orange in colour. Causes smaller leaves, sooty mould and twig dieback on *Magnolia acuminata, M. x soulangiana and M. stellata.* Nymphs of this large scale are purple in mid-summer, turning white by late summer. [**Plate 36**] Overwinter as tiny nymphs on this year's wood. [**Plate 35**] Dormant oil applications can suppress overwintering nymphs in fall and/or early spring.

MALUS — apple

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➣ *Endosulfan 400, 1.25 L ➣ *Thiodan 4 EC, 1.25 L ➣ Cygon 480 E, 1.25 L ➣ Lagon 480, 1.25 L ➣ Malathion 500 EC, 1.25 L ➣ [1]Sniper 50 W, 0.625–0.775 kg	Treat when adults first appear and repeat as required. [**Plate 37**] * *Endosulfan* and *Thiodan* are toxic to fish. [1] *Minimum re-entry period is 48 hr.*
	Codling moth (*Cydia piononella*)	➣ Confirm 240 F, 1 L/ha (330–600 mL/1000 L water)	Apply Confirm at larval hatch. Allow 3–7 days for larval mortality. Repeat application of Confirm every 14–21 days, with a maximum of 4 applications per year.
	Fall cankerworm (*Alsophila pometaria*) Spring cankerworm (*Paleacrita vernata*)	➣ Dipel 132 ES, 0.5–1.7 L/ha ➣ Foray 48 B, 1.0–1.6 L/ha ➣ Malathion 500 EC, 2.5 L ➣ Methoxychlor 240 EC, 4.0 L ➣ Sevin 50 W, 2.0–3.00 kg ➣ Thuricide, 1.5–2.0 L	Cankerworms are greenish-to-black loopers (inch worms) that appear early in the season and feed on leaves of many deciduous hosts. [**Plate 38 & 39**] Place sticky bands around tree trunks, close to the ground, in the spring and fall. This traps adult females as they emerge from the ground and crawl up the tree trunk. Treat when larvae appear in mid-May, when *Acer platanoides* and *Magnolia x soulangiana* are blooming.
	Eastern tent caterpillar (*Malacosoma americanum*)	➣ Ambush 500 EC, 70 mL ➣ Diazinon 500 EC, 925 mL ➣ Dipel 132 ES, 0.5–1.0 L/ha ➣ Foray 48 B, 1.0–1.6 L/ha ➣ Malathion 500 EC, 2.5 L ➣ Methoxychlor 240 EC, 4.0 L ➣ Pounce, 90 mL ➣ Sevin 50 W, 2.0–3.0 kg ➣ Thuricide, 1.5–2.0 L	This caterpillar has 1 yellow stripe down its back. [**Plate 40**] Colonies feed early in the season. Silken tents appear in the forks of branches, mainly of apple, cherry and hawthorn trees. Prune and destroy overwintering egg masses. These are silver in colour, about 1–2 cm long in a raised band circling a twig. They hatch when buds break in spring. Treat then or at the first sign of webs. In light infestations, remove and destroy the tents (which contain larvae).
	Gypsy moth	➣ See under *BETULA*	[**Plate 13 & 14**]
	Japanese beetle	➣ See under *ROSA*	[**Plate 74 & 75**]
	Leafrollers: Fruit tree leafroller (*Archips argyrospila*) Redbanded leafroller (*Argyrotaenia velutinana*)	➣ Methoxychlor 240 EC, 4.0 L ➣ [1]Guthion 240 EC, 4.0 L ➣ [1]Guthion 50 WP, 0.625–0.775 kg ➣ [1]APM 50 W, 1.0–1.25 kg ➣ [1]Sniper 50 W, 0.625–0.775 kg	Leafrollers are caterpillars that feed while hidden in folded or rolled leaves. Fruit tree and redbanded leafrollers primarily affect fruit trees, but also attack many shade trees and ornamentals. Apply to foliage soon after leaves unfold in early June. [1] *Minimum re-entry period is 48 hr.*
	Leafhopper (Several species)	➣ [1]Guthion 240 SC, 1.75–2.5 L ➣ [1]Guthion 50 WP, 0.625–0.775 kg ➣ [1]APM 50 W, 1.0–1.25 kg ➣ Imidan 50 WP, 1.25 kg ➣ Sevin 50 W, 2.0 kg ➣ Methoxychlor 240 EC, 4.0 L ➣ [1]Sniper 50 W, 0.625–0.775 kg	Check regularly for infestation when cutting alfalfa or hay. Injury appears as yellowish flecks on the leaf surface. [**Plate 41**] Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required. [1] *Minimum re-entry period is 48 hr.*

MALUS — apple (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Oystershell scale (*Lepidosaphes ulmi*)	➣ Superior oil, 20 L ➣ Ethion superior oil, 20 L ➣ Diazinon 500 EC, 1.25 L ➣ Malathion 500 EC, 2.5 L	Attacks over 125 species of forest, shade, fruit and ornamental trees. In heavy infestations, greyish scales completely encrust twigs and stems and can kill branches and trees. Mature females are 3 mm long and rounded in the rear. Use Superior oil or Ethion superior oil as a dormant treatment. Use any of other materials against crawlers in late May. Repeat in 10 days, when *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches and leaf bottoms.
	Mites: European red mite (*Panonychus ulmi*) Two-spotted spider mite (*Tetranychus urticae*)	➣ Superior oil, 20 L ➣ Ethion superior oil, 20 L ➣ Vendex 50 W, 0.5–1.0 kg	Apply oil when plants show ½ inch of green tissue and to flower buds showing as a tight cluster. This can improve control of European red mite. Two-spotted spider mite does not overwinter on the plant and is not controlled by the oil treatment.
DISEASES	Cedarapple rust (*Gymnosporangium juniperi-virginianae*)	➣ Daconil 2787 F, 2.5 L ➣ Ferbam 76 WDG, 1.25–2.25 kg ➣ Nova W, 340 g ➣ Polyram 80 DF, 2.0 kg ➣ Zineb 80 WP, 1.25 kg	Orange spots on leaf surface appear in early summer, followed by crème-coloured, finger-like structures on underside of leaves by mid- to late summer. Remove alternate hosts (Junipers) where possible. Treat with Nova when sporulation (slimy orange galls) begins on alternate host (Juniperus), in mid-spring. Spores from Juniper can infect alternate Rosaceous hosts (*Malus*, *Crataegus*, *Amelanchier*, etc.). Repeat fungicidal applications every 10–14 days if needed. Apply other registered fungicides twice to foliage, starting at spring bud break. To avoid resistance, rotate Nova with registered fungicides from other chemical families.
	Fire blight (*Erwinia amylovora*)	➣ Copper Spray, 1.25 kg	Dead, dry leaves persist on infected branch. [**Plate 42**] Spray at early bloom, full bloom and petal fall where weather is warm and humid, and fire blight is a recurring problem. Fire blight affects succulent vegetative growth. Avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry. Some cultivars are resistant.
	Apple scab (*Venturia inaequalis*)	➣ Banner 130 EC, 170 mL ➣ Captan 50 WP, 2.0 kg ➣ Captan 80 WDG, 1.25 kg ➣ Cyprex 65 WP, 500 g ➣ Daconil 2787 F, 2.5 L ➣ Nova 40 W, 340 g ➣ Polyram 80 DF, 2.0 kg	Infection causes lesions on leaves and fruit. [**Plate 43**] Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during spring, especially in rainy weather. Nova and Banner are triazole fungicides. Rotate their use with fungicides of other chemical families to manage resistance. Do not exceed a maximum of 4 applications of Banner per year. (Banner is registered for use on ornamental and non-bearing apples only.) If disease spread stops after new leaves harden off, cease fungicide treatment. Clean up and remove/destroy fallen leaves. Prune to improve air circulation through the canopy. Plant resistant cultivars.
	Powdery mildew (*Podosphaera leucotricha*)	➣ Nova 40 W, 340 g	Whitish powder develops on the tops of leaves in summer, may lead to stunting and leaf drop. Treat with Nova when symptoms first appear. Repeat every 10–14 days as needed. To avoid resistance, rotate with registered fungicides from other chemical families where possible.

PACHYSANDRA — pachysandra

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Euonymus scale	➣ See *EUONYMUS*	[**Plate 20 & Plate 21**]

PICEA — spruce

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cooley spruce gall adelgid (*Adelges cooleyi*)	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Malathion 500 EC, 1.25 L ➢ Pyrate 480 EC, 375 mL ➢ Sevin 50 W, 2.0–3.0 kg	Long, plump galls form on the current year's shoots of blue Colorado spruce, Engelmann spruce and Sitka spruce. [**Plate 44**] Douglas fir is an alternate host [**Plate 45**]. Causes needles to twist and turn yellow, but does not form a gall. Treat in early spring before bud break or in early October. Thoroughly cover crevices in the bark of terminal twigs and the bases of buds. On blue spruce, use only wettable powders to prevent foliage discoloration. If possible, remove and destroy galls in June. * *Endosulfan and Thiodan are toxic to fish.*
	Eastern spruce gall adelgid (*Adelges abietis*)	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 1.25 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Pineapple-shaped galls form at the base of current year shoots on Norway, white, red and black spruce. [**Plate 46**] Old galls remain attached for long periods, turning black and making the tree look scraggly. With light infestations, remove and destroy galls before midsummer. Use Superior oil or Ethion superior oil as a dormant treatment. Use any of the other materials when aphids migrate to new shoots in mid-May. On blue spruce, use only wettable powders to prevent foliage discoloration and avoid Superior oil and Ethion superior oil. * *Endosulfan and Thiodan are toxic to fish.*
	June beetle, European chafer (*Phyllophaga* sp., *Rhizotrogus majalis*)	Beetle larvae chew fibrous roots and girdle underground stems of many woody ornamentals (including *Picea* sp.). Till infested fields before planting, to expose grubs to natural predators.	
	Pine needle scale	➢ See under *PINUS*	[**Plate 54 & 55**]
	Spruce budworm (*Choristoneura fumiferana*) Also see under *ABIES*	➢ Ambush 500 EC, 35–70 mL ➢ Cygon 480 E, 1.25 L ➢ Dipel 132 ES, 1.2–2.4 L/ha ➢ Foray 48 B, 1.6–2.4 L/ha ➢ Lagon 480, 1.25 L ➢ Lannate L, 1.25–1.75 L ➢ Malathion 500 EC, 2.5 L ➢ Mimic 240 LV, 290 mL/ha ➢ Sumithion 50 EC, 0.35–0.56 L	A widespread and important defoliator of balsam fir and spruce. Begins to feed as buds break and continues until mid- to late June. Seldom a problem on landscape trees. Larva has a black head and brownish body with 4 light spots on the back of each segment. [**Plate 1**] One generation per year. In mid-spring, apply general coverage spray to control larvae. Use Mimic to control early instar larvae, allow 3–7 days for larval mortality. A second application of Mimic may be needed. In balsam fir, overwintering larvae become active about 2 weeks before bud break. Apply general coverage spray to control larvae from mid-May to mid-June.
	Spruce bud scale (*Physokermes piceae, P. hemieryphus*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 2.5 L ➢ Superior oil, 20 L	A globular, mahogany-brown scale that clusters on spruce. Lower branches become ragged, with some dieback. Monitor for honeydew and sooty mould. Spray to control the crawlers in mid-July. Repeat 10 days later.
	Spruce spider mite (*Oligonychus ununguis*)	➢ Cygon 480 E, 1.25 L ➢ Lagon 480, 1.25 L ➢ Malathion 500 EC, 1.25 L ➢ Orthene 75 SP, 1.0 kg ➢ Pentac Aquaflow, 400 mL ➢ Pyrate 480 EC, 375–500 mL ➢ Superior oil, 20 L ➢ Vendex 50 W, 0.5–1.0 kg	Overwintering eggs hatch in late April and early May, when *Amelanchier* and *Acer platanoides* bloom. Young nymphs can be controlled by chemicals. Pests prefer older needles as feeding sites. [**Plate 47**] Many predacious mites control populations. Use Superior oil as a dormant treatment in early spring. On blue spruce, use only wettable powders to prevent foliage discoloration and avoid Superior oil and Ethion superior oil. Then apply 2 sprays of other materials at 10–day intervals when mites exist in summer. Use miticides alone for maximum effectiveness. To monitor for mites, shake a branch over a white sheet of paper and look for crawling mites.
	Spruce needleminer (*Taniva albolineana, Endothenia albolineana*)	➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1.0 kg	Larvae bore into the bases of old needles. Young larvae feed in groups, while older larvae feed alone. Builds unsightly nests of dead needles and frass, held together by fine silk strands. [**Plate 48**] Small grey moths appear throughout infested plants in late May and June. Apply control to foliage about mid-June and repeat in late June. In fall, or in spring before buds swell, dislodge nests with a strong water stream.

PICEA — spruce (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Strawberry root weevil (*Otiorhynchus ovatus*)	➣ Ambush 500 EC, 500 mL	Larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish brown flightless adult is under 6 mm long and resembles the black vine weevil. Hides during the day and feeds at night. These pests have a large host range. Commonly injured plants include white cedar, spruce and juniper. Adults are active in late June and early July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing or girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow and look dry and off-colour. Transplants often die without becoming established. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. Ambush is registered for use on seedlings. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety.
	Tarnish plant bug	➣ See under *THUJA*	[**Plate 86**]
	White pine weevil	➣ See under *PINUS*	[**Plate 64 & 65**]
DISEASES	Botrytis	➣ See under *THUJA*	Seedlings.
	Canker Branch Dieback (*Cytospora valsa*)	Kills individual, scattered lower branches. [**Plate 49**] First symptoms are browning and needle loss. Norway and Colorado spruce are very susceptible. Prune out diseased branches and twigs when bark is dry. Maintain good growing conditions. Avoid damaging trunk and branches.	
	Needlecast (*Rhizosphaera kalkhoffii*)	➣ Copper Spray, 4.0 kg ➣ Daconil 2787 F, 9.5 L	Often becomes apparent between early spring and early summer when needles infected the previous season turn purple or lavender. [**Plate 50**] By mid-season, infected needles drop leaving only current season growth. Blue Colorado spruce is very susceptible. Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.
	Tip blight (*Sirococcus conigenus*)	➣ Copper Spray, 4.0 kg ➣ Daconil 2787 F, 3.6–6 L	Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Do not crowd plants. Maintain adequate sunlight and good air circulation.

PINUS — pine

	Pest	Control/1000 Litres Water	Remarks
INSECTS	European pine shoot moth (*Rhyacionia buoliana*)	➣ [1]Guthion 50 WP, 0.85–1.75 kg ➣ Cygon 480 E, 2.5 L ➣ Diazinon 500 EC, 1.5 L ➣ DZN 600 EW, 1.25 L ➣ Sevin 50 W, 2.0–3.0 kg ➣ [1]Sniper 50 W, 0.85–1.75 kg	Brown larvae with black heads feed on growing shoots in spring. [**Plate 51**] This causes "hooking" of new candles. Adult is a small, orange-flecked moth, usually active in late June to early July. Egg hatch coincides with the bloom of *Catalpa speciosa*. One generation per year. In late April, apply spray to area between buds on terminals and laterals. Do this when *Acer rubrum* and *Cornus mas* are blooming. Spray terminals about mid-July to prevent injury the following year. If you delay shearing to mid-July, many eggs will be destroyed. Use pheromone traps to monitor for adult activity. [1] *Minimum re-entry period is 48 hr.*
	Gypsy moth	➣ See under *BETULA*	
	June beetle, European chafer (*Phyllophaga* sp., *Rhizotrogus majalis*)	➣ Sevin XLR PLUS, 2.3–3.5 L	Beetle larvae chew fibrous roots and girdle underground stems of many woody ornamentals (including *Pinus* sp.). Till infested fields before planting, to expose grubs to natural predators. Sevin XLR PLUS is registered as a foliar spray for adults.

PINUS — pine (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Northern pine weevil (*Pissoides approximatus*)	➢ Methoxychlor ➢ Sevin 50 W, 2.0–3.0 kg	Can be a problem on all pines, especially in Christmas tree production. Often found on *Pinus sylvestris*. Damage includes flagging and browning of new shoots and seedlings. May cause small circular wounds at the base of the damage that exude pitch resin. Remove freshly cut stumps and recently dead and dying trees by late spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To control adults, treat tender bark of seedlings and young shoots of larger trees in April or late August.
	Pales weevil (*Hylobius pales*)	➢ Methoxychlor ➢ Sevin 50 W, 2.0–3.0 kg	A small, brownish weevil that feeds on tender pine twig bark, causing the terminals to turn brown and die. [**Plate 52**] A problem in Christmas tree production. White, legless larvae have brown heads. Larvae feed in long underground tunnels along the wood grain and on the outside of major roots. Remove freshly cut stumps and recently dead and dying trees by late spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To control adults, treat tender bark of seedlings and young shoots of larger trees in April or late August.
	Pine bark adelgid (*Pineus strobi*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 1.25 L ➢ Orthene 75 SP, 1.0 kg ➢ Superior oil, 20 L	Mainly affects white pine, though other pines can be infested. Causes white, woolly masses on trunks, stems and branches. [**Plate 53**] In early spring, use Superior oil or Ethion superior oil on trunk and branch bark as a dormant treatment. Do not apply oil to white pine. Apply other materials to active nymphs in late May. Repeat application in 2–3 weeks. Ensure good coverage.
	Pine needle scale (*Chionaspis pinifoliae*)	➢ Cygon 480 E, 1.25 L ➢ DZN 600 EW, 1.25 L ➢ Ethion superior oil, 20 L ➢ Lagon 480, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1.0 kg ➢ Superior oil, 20 L	Reddish crawlers appear in late May, then turn yellowish. [**Plate 55**] Causes whitish spots on pine and spruce needles. [**Plate 54**] Two generations per year. Infestations often start on lower branches. Prune out small infestations in late winter and early spring. Use a Superior oil or Ethion superior oil as an early spring dormant treatment. Do not apply oil to white pine. Crawlers are active when *Syringa vulgaris* and *Spiraea x vanhouttei* are blooming in late May. Treat at that time and again about 10 days later.
	Pine pitch mass borer (*Vespamima pini, SynanthEdon pini*)		White and pink larvae affect established pines in the landscape. [**Plate 57**] Large pitch resin masses appear on trunks. [**Plate 56**] Has a 2–3 year life cycle. Stressed and wounded plants are most susceptible. Maintain good tree health — no registered chemical controls exist. Larvae and pupae are found under the pitch masses in May and June. They can be picked off and killed. Remove severely infested trees.
	Pine root collar weevil (*Hylobius radicis)*		Feeds on all pines, with Scots and Austrian being most susceptible. Problem areas often appear in isolated pockets or on sandy soils. The white, legless, grub-like larvae feed at the root collar. This causes the trunk to swell. Pitch resin masses mixed with soil also appear. Prune off bottom branches. Pull away fallen needles and other organic matter to expose a circular soil surface 30 cm from the trunk. This increases light and temperature at the tree base, discouraging adult weevils. In mid-June, treat bark with registered insecticides at trunk base and the soil surface 20 cm out from the trunk. This controls adults and developing larvae.
	Pine sawflies: European pine sawfly (*Neodiprion sertifer*) Redheaded pine sawfly (*Neodiprion lecontei*)	➢ Ambush 500 EC, 35–70 mL ➢ Cygon 480 E, 1.25 L ➢ Lagon 480, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Orthene 75 SP, 1.0 g ➢ Pyrate 480 EC, 500 mL ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Sumithion 50 EC, 0.56 L or 0.35 L twice	European pine sawfly has a dark-greenish body with dark longitudinal stripes and a black head. [**Plate 58**] It appears in late May/June. Redheaded pine sawfly has a yellow body with 6 rows of black spots and a reddish head. [**Plate 59**] It feeds on older foliage in July and August. Multiple generations can be present at one time and will attack all foliage. Initial feeding begins in small, easily removed colonies. Spot-treat foliage when small larvae feeding first observed. Apply Sumithion at this time and repeat in 4–6 days.

PINUS — pine (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Pine shoot beetle (*Tomicus piniperda*)	This introduced bark beetle was found in Ohio in 1992 and in Ontario in 1993. By 1994, it was declared a quarantinable pest. Pines from many areas of the province are subject to quarantine. The primary host is Scots pine, *Pinus sylvestris*. The 3 mm long adult beetles tunnel within the current season's growth [**Plate 63**], causing flagging and dropping of shoots. [**Plate 62**] Adult beetles overwinter at the base of trees (30 cm), just inside the outer bark. The adults start to emerge in February–March, when temperatures reach 10°C. They bore into bark to lay their eggs, causing sap to flow out of these wounds. [**Plate 60**] The larvae form galleries in the bark thereby destroying the cambium and weakening/killing the tree. [**Plate 61**] Maintain plant health — no registered chemical controls exist. Do not plant nursery pines and Christmas trees near abandoned pine plantations. To discourage egg laying, remove stumps, pine debris, dying trees and pruned limbs from the area by Feb.1. Place out uninfested "trap logs" (diameter greater than 6 cm) out to attract mating adults and destroy them by May 31. Contact the Canadian Food Inspection Agency for the Pest Alert Factsheet on PSB.	
	Pine spittlebug (*Aphrophora cribrata*)	➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Pyrate 480 EC, 88–150 mL ➢ Sevin 50 W, 2.0–3.0 kg	Several different pines are susceptible hosts, with Scots pine often heavily infested. Young nymphs feed on sap from new growth and cover themselves with white, foam-like spittle. Several nymphs may be found in 1 spittle mass. This pest rarely causes serious damage. Treat when spittle masses first appear in mid-late May.
	Pine tortoise scale (*Toumeyella numismaticum, T. parvicornis*)	➢ DZN 600 EW, 1.25 L ➢ Ethion superior oil, 20 L ➢ Malathion 500EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	This reddish-brown oval, convex scale, about 6 mm long, infests several kinds of pine. It removes plant sap and secretes large amounts of honeydew. Remove heavily infested limbs and trees in late winter and early spring. In late June, treat twigs to control nymphs. There are several natural predators.
	Pine webworm (*Tetralopha robustella*)	➢ Methoxychlor 240 EC, 4.0 L	A yellowish-brown larva with 2 dark longitudinal stripes on each side. In midsummer, larval colonies feed on needles. These are enclosed in coarse-webbed frass masses on twigs and branches. Apply spray under sufficient pressure to penetrate the webbing. In light infestations, hand pick or prune infested tips.
	Spruce spider mite	➢ See under *PICEA*	Do not apply oil on white pine.
	Strawberry root weevil	➢ See under *PICEA*	
	Tarnish plant bug	➢ See under *THUJA*	[**Plate 86**]
	White pine aphid (*Cinara strobi*)	➢ Cygon 480 E, 2.0 L ➢ Lagon 480, 2.0 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 375 mL	Aphids often cluster together on shoots. Look for honeydew and sooty mould on needles. Treat active stages in May.
	White pine weevil (*Pissodes strobi*)	➢ Methoxychlor 240 EC, 4.0 L	A small, brownish snout beetle that attacks only vertical terminals on pines and spruce. [**Plate 64**] It kills at least 2 years growth. Attacks cause crooked, forked, or multiple-stemmed trees. Legless, white larvae are found in the terminal shoots. [**Plate 65**] In April, spray the vertical terminals. Remove and destroy infested, flagging leaders in June and July.
	Zimmerman pine moth (*Dioryctria zimmermani*)	➢ Cygon 480 E, 2 L ➢ Lagon 480, 2.0 L	Grey-green larvae cause pitch resin to collect on pine trunks. Pitch masses appear at the branch whorls, on the trunk, or on shoots near terminal branches. Individual branches may die back completely. Remove larvae from pitch masses in June and July. Prune damaged shoots and remove heavily infested trees. Chemical control is difficult. Spray bark thoroughly in late April to early May when overwintering larvae are breaking dormancy (when *Acer platanoides* is blooming). Treat again in mid-August. when larvae hatch. Use pheromone traps to monitor adult activity.

PINUS — pine (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Canker (*Ascocalyx abietina* or *Scleroderris abietina*)	➣ Daconil 2787 F, 2.4–4.8 L	Affects many pines, especially Scots and red pine. Trees under 2½ m are most susceptible. Symptoms appear in spring after infection. Bases of infected needles turn reddish brown by May or June. Needles may be bent. Cool moist weather encourages infection. To reduce spread, prune out lower branches of pine windbreaks around nurseries. Apply treatment in spring when new growth reaches 1–5 cm. Repeat at 3–4 week intervals.
	Diplodia tip blight (*Sphaeropsis sapinea* or *Diplodia pinea*)	➣ Copper Spray, 4.0 kg	New shoots do not elongate in spring and are stunted by June. [**Plate 66**] Maintain tree health, since infection is hard to control. Apply fungicides at bud break — maximum 3 applications per year at 2-week intervals. Removing infected branches does not reduce infection, since spores are also produced on seed cones. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Lophodermium needlecast (*Lophodermium seditiosum*)	➣ Copper Spray, 4.0 kg ➣ Daconil 2787 F, 2.4–4.8 L ➣ Dithane M-45, 80 WP, 2.5 kg	Previous season's needles turn red in late winter and early spring. [**Plate 67**] Infected needles drop from late spring to early summer. Black football-shaped fruiting bodies appear on cast needles in mid-summer. Severely defoliates pines, especially Scots and Austrian pine. Only current season's needles remain on the tree over winter. Apply treatment in mid-July to early August before infection occurs. Repeat at 3–4 week intervals as required. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Tip blight (*Sirococcus*)	➣ Copper Spray, 4.0 kg ➣ Daconil 2787 F, 3.6–6 L	Apply treatment in spring when new growth is 12 cm long. Repeat at 3–4 week intervals. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Brown spot (*Scirrhia*)	➣ Daconil 2787 F, 9.5 L	Apply treatment in spring when new growth is 12 cm long. Repeat at 3–4 week intervals. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Sweetfern blister rust (*Cronartium comptoniae*)	Affects hard 2- and 3-needle pines, especially jack pine (*Pinus banksiana).* Can cause serious losses in nurseries and young plantations. Cankers often appear below 2½ m on the trunk. Trees with >8 cm basal diameters seem resistant. Destroy diseased pines. Eliminate alternate hosts like sweet fern (*Comptonia peregrina*) and sweet gale (*Myrica gale*), from plantations and from the immediate vicinity of pine nursery stock.	
	White pine blister rust (*Cronartium ribicola*)	A serious disease of 5-needle pines, especially native white pine, *Pinus strobus.* Infects the needles, eventually causing a perennial canker on branches and stems. [**Plate 68**] Can also cause an insignificant leaf spot. Prune out girdled pine branches before the canker reaches the main stem. Prune infected, flagging branches 30 cm below the cankered area. Separate white pine nurseries and plantations from alternate host *Ribes* sp. by 600 m.	

PLATANUS — London plane, Sycamore

	Pest	Control/1000 L Water	Remarks
DISEASES	Anthracnose (*Apiognominia veneta*)	➣ Daconil 2787 F, 2.5 L ➣ Mancozeb 80 WP, 2.7 kg	As with frost damage, new leaves turn black-brown. Light brown dead areas appear along veins of mature leaves. Twigs 20–25 cm long may show signs of dieback. Treat up to 3 times, especially in cool, wet weather: as buds swell, at bud break and about 7 days later. Prune out and destroy cankered twigs and branches. Collect and remove fallen, infected leaves. Do not crowd plants — maintain adequate sunlight and good air circulation.

POPULUS — poplar

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Forest tent caterpillar	➢ See under *ACER*	
	Poplar and willow borer (*Cryptorhynchus lapathi*)	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4 EC, 1.25 L ➢ Pyrate 480 EC, 500 mL	A stout, black, rough-bodied snout beetle with pink outer wing covers. White, legless larvae honeycomb the trunks and larger branches of willows and poplars. Cut and destroy badly infected branches and trees before the end of June. Treat trunk and branch bark in mid-August and September. **Endosulfan and Thiodan are toxic to fish.*
	Gypsy moth	➢ See under *BETULA*	
DISEASES	Canker (Several different fungi)	Most poplar species are susceptible, especially when stressed. Prune out and destroy infected branches during dry weather. Remove and destroy severely infected trees. Do not wound or injure trees. Do not crowd plants — maintain adequate sunlight and good air circulation.	
	Leaf spot (Several fungi)	➢ Daconil 2787 F, 2.5 L ➢ Senator 70 WP, 1 kg in 1,000 L water/ha	Brown spots appear on leaves, followed by defoliation. Collect and remove fallen infected leaves. Treat at bud break, then twice more at 10–14 day intervals. Applications of Senator can be repeated every 10–14 days with a maximum of 3 applications per year.

PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4 C, 1.25–1.75 L ➢ [1]Sniper 50 W, 0.925–1.25 kg ➢ Malathion 500 EC, 1.25 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 375 mL	Treat when adults first appear and repeat as required. Excessive fertilization or pruning can cause undesirable succulent growth levels. * *Endosulfan and Thiodan are toxic to fish.* [1] *Minimum re-entry period is 48 hr.*
	Eastern tent caterpillar	➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 375 mL ➢ See under *MALUS*	[**Plate 40**]
	Japanese beetle	➢ See under *ROSA*	[**Plate 74 & 75**]
	Leafroller	➢ Orthene 75 SP, 1.0 kg ➢ See under *MALUS*	
	Peachtree borer (*Synanthedon exitiosa*) Lesser peachtree borer (*Synanthedon pictipes*)	➢ *Endosulfan 50 W, 1 kg ➢ *Thiodan 4 EC, 1.5 L	Peachtree borers attack tree/shrub bases of ornamental Prunus (e.g. *Prunus x cistena*). [**Plate 70**] Lesser peachtree borers attack higher limbs and are found mainly on fruit trees *Prunus* sp. [**Plate 69**] Adults are clear-winged moths and resemble wasps when flying. Borers overwinter in bark or wood as partly grown larvae. Feeding resumes in spring, with gum and frass accumulating near the burrows. Treat mid- to late spring, when *Philadelphus* is blooming. Repeat twice at 3-week intervals. Spray with a gun and cover trunk and scaffold limbs thoroughly. Use pheromone traps to monitor adult activity. **Endosulfan* and *Thiodan* are toxic to fish.
	Pearslug	➢ Orthene 75 SP, 1.0 kg ➢ See under *MALUS*	
	Uglynest caterpillar (*Archips cerasivorana*)	➢ Methoxychlor 240 EC, 4.0 L ➢ Sevin 50 W, 2.0–3.0 kg	Dark, yellow-green larvae have black heads. Mainly attacks low-growing shrubs. Feeds on choke, pin and black cherry. Webbed nests appear at branch ends between May and September. Prune out nests when found. Chemical control seldom used.

PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Bacterial canker (*Pseudomonas syringae*)	➣ Clean Crop Copper Spray, 6.0 kg	Apply before autumn rains and again when most leaves have fallen. Do not crowd plants — maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth that is susceptible to this disease. Often develops after poly is removed from cold frames (container production).
	Blossom and twig blight (*Monilina fructicola*)	➣ Captan 50 WP, 2.0 kg ➣ Captan 80 WDG, 1.25 kg ➣ Cyprex 65 WP, 500 g ➣ Daconil 2787 F, 2.5 L ➣ Funginex 190 EC, 750 mL ➣ Sulfur 90–95 WP, 2.0 kg	Spring blossoms suddenly collapse and turn brown. Shoot or twig blight appears in early spring. Fruit will turn brown, rot and hang on the tree. Spray just before blossom buds open. Repeat in 10 days if wet weather persists. Prune out and destroy infected twigs. Remove infected fruit from tree and the adjacent ground.
	Black knot (*Apiosporina morbosa* or *Dibotryon morbosa*)	Large black swellings up to 10 cm long on branches and small twigs eventually girdle and kill the branch. In late winter and early spring, prune and destroy infested twigs and branches 20–30 cm below knots. Eliminate wild or neglected *Prunus* species from the area.	
	Peach leaf-curl (*Taphrina deformans*)	➣ Ferbam 76 WDG, 1.75–3.5 kg	As leaves unfold in spring, they become puckered and curled. Thickened areas eventually turn pinkish. Infected leaves become weakened and drop. Spores lodged in winter buds cause infections during spring. Apply fungicide in fall (preferred time) just after complete leaf drop OR apply in early spring just before buds swell.
	Shothole leaf spot (*Blumeriella jaapii*)	➣ Captan 80 WP, 1.25–1.5 kg	Leaf spots appear as leaves reach full size. New spots appear until late summer. Disease spots fall out with age, giving a shothole appearance. (Other problems cause similar symptoms.) Avoid overhead irrigation late in the day. Do not crowd plants — maintain adequate sunlight and good air circulation.

PSEUDOTSUGA — Douglas Fir

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cooley spruce gall aphid	➣ See under *PICEA*	[**Plate 44**]
	Tarnish plant bug	➣ See under *THUJA*	[**Plate 86**]

PYRACANTHA — firethorn

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Scab (*Spilocaea pyracanthae*)	➣ Banner 130 EC, 170 mL ➣ Daconil 2787 F, 2.5 L	Infection causes dark zones on leaves that develop into yellow lesions. Infected leaves may drop and dull scabs may appear on twigs and fruit. Plant scab-resistant cultivars. Clean up and destroy fallen leaves. Prune to improve air circulation through the canopy. Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during mid-spring, especially in rainy weather. Apply Banner every 14 days, beginning at green tip of leaf buds. Rotate Banner with fungicides from other chemical families to avoid resistance. Do not exceed 4 applications of Banner per year. Stop treatments if no infection exists when foliage is hardened off.
	Fire blight	➣ See under *MALUS*	[**Plate 42**]

PRYUS — pear

	Pest	**Control/1000 Litres Water**	Remarks
DISEASE	Fire blight	➣ See under MALUS	[**Plate 42**]

QUERCUS — oak

	Pest	**Control/1000 Litres Water**	**Remarks**
INSECTS	Aphid	➣ See under *FAGUS*	
	Cankerworm	➣ Orthene 75 WP, 1.0 kg ➣ See under *MALUS*	[**Plate 38 & 39**]
	European fruit lecanium	➣ See under *ULMUS*	[**Plate 4**]
	Golden oak scale (*Asterolecanium variolosum*)	➣ Cygon 480 E, 2.5 L ➣ Ethion superior oil, 20 L ➣ Lagon 480, 2.5 L ➣ Orthene 75 SP, 1.0 kg ➣ Pyrate 480 EC, 2.0 L ➣ Sevin XLR PLUS, 2.3–3.5 L ➣ Superior oil, 20 L	Yellowish-golden scale feeds in small pits on white and English oak twigs, branches and trunks. Can cause branch dieback. Use Superior oil or Ethion superior oil as a dormant treatment in early spring. Use any of the other materials against crawlers in late June. Crawlers can appear on first year and current season wood.
	Gypsy moth	➣ See under *BETULA*	[**Plate 13 & 14**]
	Lacebug	➣ See under *FRAXINUS*	
	Lecanium scale	➣ See under *THUJA*	
	Oak leafminer (*Profenusa lucifex*)	➣ DZN 600 EW, 830 mL ➣ Diazinon 500 EC, 1.0 L ➣ Malathion 500 EC, 2.5 L ➣ Orthene 75 SP, 1.0 kg ➣ Sevin 50 W, 2.0–3.0 kg	Causes flat, blister-like mines from mid-June to July. Pale larvae with stubby black legs found in mines. Early treatment is most effective. Treat foliage to control larvae beginning the first week of June.
	Oak leaf gall (Several species)	➣ Chemical control usually not necessary	Many gall makers infest oak roots, bark, twigs, leaves, [**Plate 71**] flowers and acorns. Each gall has a characteristic appearance. Many are conspicuous and interesting, but few cause serious damage.
	Oak leaftier (*Croesia semipurpurana*)	➣ Sevin 50 W, 2.0–3.0 kg ➣ Sevin 80 S, 1.25–2.0 kg	Attacks only oaks. Small, whitish larvae enter unopened buds in May. They feed on the young leaves, then tie the leaves together and shred the tissue. Treat to control larvae when leaves are partially expanded.
	Oak red mite (*Oligonychus bicolor*)	➣ Kelthane 187.5 EC, 2.5 L ➣ Orthene 75 SP, 1.0 kg	Feeding bronzes and bleaches oak leaves. Treat upper leaf surface from mid-June to mid-July. Weather and predators often keep populations under control.
	Oak skeletonizer (*Bucculatrix ainsliella*)	➣ Malathion 500 EC, 2.5 L ➣ Sevin 50 W, 2.0–3.0 kg	Small yellowish-green larvae skeletonize the lower surface of oak leaves. One generation in June and a second in August/September. Treat foliage when damage first appears in mid-June. Repeat in August. Collect and destroy leaves in the autumn.
	Orangestriped oakworm (*Anisota senatoria*)	➣ Malathion 500 EC, 2.5 L ➣ Methoxychlor 240 EC, 4.0 L ➣ Sevin 50 W, 2.0–3.0 kg ➣ Sevin 80 S, 1.25–2.0 kg	The black larvae have orange or yellow stripes running lengthwise down the sides and back. Two stiff black horns project from the top of the second body segment. Small sharp spines on the other body segments. If necessary treat in August when larvae are young and concentrated on the lower branches.
	Oak twig pruner (*Elaphidionoides villosus*)	A long-horned beetle that attacks oak and some other deciduous trees. Larvae tunnel inside the twigs. Foliage on infested branches begins to wilt in mid-summer, damaged twigs fall to the ground. Collect and destroy fallen twigs before mid-May and in the autumn to remove pupae. Chemical control is difficult and impractical.	

QUERCUS — oak (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Red oak clearwing moth (*Paranthrene simulans*)		Larvae bore into the wood of red oak trees, causing dieback in the canopy and sometimes tree mortality. Adults are clearwing moths and resemble wasps when they are flying. Look for large holes with sawdust on tree trunks. [**Plate 72**]. Bore holes and tunnels often ascend up into the trunk. Insert a piece of flexible wire in the bore hole to destroy larvae. Monitor adult populations with clearwing moth pheromone traps in late spring. High densities of pheromone traps may interrupt mating in small stands of red oak.
DISEASES	Anthracnose (*Gnomonia quercina* or *Apiognomonia quercina*)	➢ Daconil 2787 F, 2.5 L ➢ Dithane M-45, 2.75–3.5 kg	Causes irregular leaf-margin browning on red and white oak. Areas between veins also turn brown. Often develops after a cool, wet spring. Collect and destroy fallen leaves in the fall. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Chlorosis or Leaf yellowing	A problem for pin oak (*Quercus palustris*) and red oak, (*Q. rubra*), on high pH soils (pH>6). Also caused by poor soil conditions such as water logging and compaction.	
	Dieback	➢ See *ABIOTIC DISEASES*	
	Leaf spot Several fungi	➢ Daconil 2787 F, 2.5 L	Well defined brown or black spots appear in the leaves. Treat when dormant or at bud swell. Maintain plant health. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Scorch	➢ Abiotic	Irregular browning appears on leaf margins and between veins. Occurs late in the season and during dry weather. [**Plate 73**]

RHODODENDRON — rhododendron, azalea

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil	➢ See under *TAXUS*	[**Plate 80 & 81**]
DISEASES	Dieback (*Phytophthora*)	➢ Daconil 2787 F, 2.5 LT	Canker visible on the stem. Terminal buds and leaves turn brown and leaves droop and curl. May also affect the root (water-soaked, brown roots) and crown. Treat with Daconil as new leaves emerge. Repeat every 7–14 days during wet weather. Prune out infected branches and avoid overhead irrigation late in the day. Do not crowd plants — maintain adequate sunlight and good air circulation. Maintain media air porosity, reduce watering where root rot exists. Do not grow near lilacs, a common host for this disease.
	Powdery mildew	➢ Banner 130 EC, 420 mL	White, powdery growth appears on leaves especially during hot days and cool nights. Apply Banner at the first sign of disease, every 14 days as required. Rotate Banner with fungicides from other chemical families to avoid resistance. Do not exceed a maximum of 4 applications per year.

ROBINIA — locust

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Locust borer (*Megacyllene robiniae*)	➣ *Endosulfan 400, 1.25 L ➣ *Thiodan 4 EC, 1.25 L ➣ Pyrate 480 EC, 500 mL	Larvae are fleshy, white grubs that tunnel in black locust stems. Black and yellow beetles feed on goldenrod pollen in late summer. Weakened trees break in the wind. Remove and destroy heavily infested trees. Maintain tree vigour — chemical control is difficult. Treat bark or trunk and larger branches to control adult beetles from mid-August to late September (when goldenrod is blooming). * *Endosulfan and Thiodan are toxic to fish.*
DISEASES	Locust leafminer (*Odontota dorsalis*)	➣ Orthene 75 SP, 1.0 kg ➣ Sevin XLR PLUS, 2.3–3.5 L	Damages black locust leaves in adult and larval stages. Heavy infestations make trees unsightly. Two generations a year. The adult is a small, wedge-shaped black beetle with bright orange wing covers. To control adult beetles, treat foliage in spring, when leaves open fully and in early July.

ROSA — rose

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➣ Cygon 480 E, 1.25 L ➣ See under *FAGUS*	
	Leafhopper	➣ See under *GLEDITSIA*	[**Plate 41**]
	Japanese beetle (*Popillia japonica*)	Adult beetle control: ➣ Imidan 50 WP, 1.25 kg ➣ Sevin XLR PLUS, 2.3–3.5 L	Metallic green adults are about 13 mm long. Easily recognized by 6 tufts of white hair on each side of the abdomen. [**Plate 75**] As the beetles feed, they skeletonize and consume foliage. [**Plate 74**] Preferred hosts include members of the *Rosaceous* family, maple, birch, linden and fruit trees. Spray when adults appear in early July, when the *Yucca filamentosa* is blooming. Use pheromone traps and lures to monitor adult activity. Larvae are "C"-shaped milky-white grubs (about 25 mm long) with brown heads and 3 pairs of legs. Distinguishable from other white grubs by a "V"-arrangement of spines on the underside of the abdomen. Larvae feed on fibrous roots of turf and herbaceous or woody ornamentals.
	Rose chafer (*Macrodactylus subspinosus*)	➣ Methoxychlor 240 EC, 4.0 L ➣ Sevin XLR PLUS, 2.3–3.5 L	A slender, long-legged, tan beetle, densely covered with short, dull yellow hairs. Beetles swarm in early June and feed on the opening buds of many hosts. They later attack the flowers, fruit and foliage. The larvae feed mostly on turf grass roots, but may attack the roots of woody ornamentals. Monitor for rose chafer in June. It is often a problem in sandy soils. With small infestations, pick off beetles by hand. Adult control is difficult. Treat foliage thoroughly when beetles appear.
	Roseslug (*Endelomyia aethiops, Allantus cinctus*)	➣ Sevin XLR PLUS, 2.3–3.5 L	These sawflies feed on leaves from late May to mid-June. Treat both leaf surfaces. *A. cinctus* may need a second treatment in mid- to late August.
	Two-spotted spider mite (*Tetranychus urticae*)	➣ Cygon 480 E, 1.25 L ➣ Diazinon 500 EC, 1.25 L ➣ Kelthane 187.5 EC, 2.5 L ➣ Lagon 480, 1.25 L ➣ Orthene 75 SP, 1.0 kg ➣ Pentac Aquaflow, 400 mL ➣ Vendex 50 W, 0.5–1.0 kg	Attacked leaves become off-coloured, stippled, or bronzed. Check leaf bottoms for mites and webs. These tiny mites have 2 distinctive black spots on their backs. Treat leaf bottoms beginning in early June and repeat as needed. Monitor for mites by vigorously shaking a branch over a sheet of white paper.

ROSA — rose (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Bacterial canker (*Pseudomonas syringae*)	➣ Clean Crop Copper Spray, 6.0 kg	Treat once in October and once in January. Treat during blight conditions in April and May with 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Do not crowd plants — maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.
	Black spot (*Diplocarpon rosae*)	➣ Clean Crop Copper 53 W, 6.0 kg ➣ Daconil 2787 F, 2.5 L ➣ Eagle WSP, 30 g/100 L (1 pouch in 280 L water) ➣ Funginex 190 EC, 1.0 L ➣ Senator 70 WP, 500–750 g	A common rose disease causing black spots on leaves. [**Plate 76**] Leaves may turn yellow and drop. Where possible, use resistant cultivars. Remove and destroy cankered canes. Where disease occurs, use fungicides every 7–10 days from mid-May (as leaves begin to emerge) until frost kills the foliage. Apply Eagle and/or Senator every 10–14 days and rotate with fungicides from other chemical families to avoid resistance. Reduce spray intervals in cool, wet weather. Avoid overhead irrigation, especially late in the day. A 6 hour period of wet foliage will permit infection to start. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Botrytis	➣ Botran 75, 1.75 kg ➣ Daconil 2787 F, 2.5 L ➣ Senator 70 WP, 500–750 g	Apply fungicide before lifting for storage. Repeat during storage. Apply fungicides at first sign of disease and repeat every 10–14 days if needed.
	Crown gall	➣ See under *EUONYMUS*	
	Powdery mildew (*Sphaerotheca pannosa* var. rosae)	➣ Banner 130 EC, 420 mL ➣ Clean Crop Copper 53 W, 6 kg ➣ Eagle WSP, 30 g/100 L water (1 pouch in 280 L water) ➣ Folpan 50 WP, 2.0 kg ➣ Funginex 190 EC, 1.0 L ➣ Meltatox, 2.5 L ➣ Nova 40 W, 340 g ➣ Senator 70 WP, 500–750 g ➣ Sulfur 90–95 WP, 6.0 kg	White powdery growth on leaves and shoot ends. Leaves become stunted and curled. Treat when symptoms first appear. Apply fungicides every 10 days. Apply Nova OR Eagle every 10–14 days and rotate with fungicides from other chemical families to avoid resistance. Senator and Banner can be applied every 10–14 days as needed. Rotate Banner with fungicides from other chemical families to avoid resistance. Do not exceed a maximum of 4 applications of Banner per year. Do not apply sulphur when temperatures exceed 27°C. Do not crowd plants — maintain adequate sunlight and good air circulation. Overhead watering *during the day* may reduce the spread and development of the disease, but avoid overhead irrigation late in the day.

SALIX — willow

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ [*]Thiodan 4 EC, 1.25–1.75 L ➢ Malathion 500 EC, 1.25 L ➢ Orthene 75 SP, 1.0 kg ➢ Pyrate 480 EC, 375 mL ➢ [1]Sniper 240 E, 1.75–2.5 L	Treat when aphids first appear and repeat as needed. [*] *Endosulfan* and *Thiodan* are toxic to fish. [1] *Minimum re-entry period is 48 hr.*
	Gypsy moth	➢ See under *BETULA*	
	Imported willow leaf beetle (*Plagiodera versicolora*)	➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 2.5 L ➢ Orthene 75SP, 1.0 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	A small, oval, metallic blue beetle. Adults and larvae skeletonize willow and Lombardy poplar leaves. Two or more generations per year. Larvae are black, slug-like grubs. Treat at first sign of leaf feeding after leaves appear, late May to early June. Repeat application in early July if necessary. A pupal parasite exists, so avoid insecticide applications at the time of pupation.
	Oystershell scale	➢ See under *FRAXINUS*	
	Poplar and willow borer	➢ See under *POPULUS*	
	Spiny elm caterpillar (*Nymphalis antiopa*)	➢ Malathion 500EC, 2.5 L ➢ Sevin 50WP, 2.0–3.0 kg	Adult is called the "mourning cloak butterfly." Larvae are black with scattered white dots and are covered with large, branched spines. They feed in groups on elm, willow and poplar. Treat when caterpillars first appear and are small.
DISEASES	Blight scab and black canker complex	➢ No chemical control	Leaves turn brown. Branches and twigs die back. Prune out infected wood. Do not crowd plants — maintain adequate sunlight and good air circulation.

SORBUS — mountain ash

	Pest	Control/1000 Litres Water	Remarks
INSECTS	European red mite (*Panonychus ulmi*)	➢ Ethion superior oil, 20 L ➢ Malathion 500 EC, 1.25 L ➢ Superior oil, 20 L	Use Superior oil and Ethion superior oil as a dormant spray in early spring. Use other materials about late May. Apply oil when plants show ½ inch of green tissue and flower buds show as a tight cluster.
	Japanese beetle	➢ See under *ROSA*	**[Plate 74 & 75]**
	Mountain ash sawfly (*Pristiphora geniculata*)	➢ [*]Endosulfan 400, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Sevin 50 W, 2.0–3.0 kg ➢ Sevin 80 S, 1.25–2.0 kg	Yellow larvae with black spots on all body segments except the last one. There are 4 lines of spots along each side of the larvae. Two broken lines run down the back. Sawflies feed in colonies from June to early August. A second generation appears from late August to early September. Young larvae feed in colonies and are easily pruned out. Treat foliage to control larvae during late spring. Repeat treatment in areas where second generation appears in August. [*] *Endosulfan and Thiodan are toxic to fish.*
	Pearleaf blister mite (*Eriophyes pyri* or *Phytoptus pyri*)	➢ Ethion superior oil, 20 L ➢ Sevin 50 W, 2.0–3.0 kg	Causes small blisters on the bottom of pear, apple and mountain ash leaves. Several generations per year. Mites overwinter under the outer bud scales, resuming activity in the spring. Apply Ethion superior oil as a dormant treatment in the spring. Apply Sevin as a foliar spray.
	Rose chafer	➢ See under *ROSA*	
DISEASES	Apple scab	➢ See under *MALUS*	[**Plate 43**]
	Fire blight	➢ See under *MALUS*	[**Plate 42**]
	Leaf spot	➢ See under *CATALPA*	

SYRINGA — lilac

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Lilac borer (*Podosesia syringae* var. *syringae*)	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4 EC, 1.25 L ➢ Pyrate 480 EC, 500 mL	Adult is a dark brown, wasp-like moth, present from late May to late July. Adult emerges through holes 1–1.5 cm in diameter. [**Plate 77**] Larvae bore into the trunk near the base. Stressed trees are most susceptible to borers. Cut and destroy infested wood before May. Prevent mechanical damage to wood and bark. Adults are clearwing moths and resemble wasps when flying. Use pheromone traps to monitor adult activity. Begin treatment 10 days after peak catch numbers. Treat trunk and large branches, especially around wounds. Repeat twice at 10-day intervals. * *Endosulfan and Thiodan are toxic to fish.*
	Lilac leafminer (*Caloptilia syringella* or *Gracillaria syringella*)	➢ Cygon 480 E, 1.25 L ➢ Lagon 480, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1.0 kg	Adult is a small, dark brown moth, active in late May to early June. Larvae are pale yellow and feed between leaf surfaces, causing brown blotches to form. [**Plate 78**] For small infestations, pick and destroy affected leaves. Treat when pest activity first appears, or apply initially in early June or immediately after flowering and repeat 6 weeks later. Privet (*Ligustrum*) is an alternate host.
	Oystershell scale	➢ See under *FRAXINUS*	
DISEASES	Powdery mildew (*Microsphaera alni*)	➢ Sulfur 90–95WP, 6.0 kg	White to grey powdery mould appears on leaves in late summer and early autumn. [**Plate 79**] Usually does not require chemical control. Do not crowd plants — maintain adequate sunlight and good air circulation. Overhead watering *during the day* may reduce the spread and development of this disease but avoid overhead irrigation late in the day. Apply fungicide when first symptoms appear in mid- to late August. Repeat at 5–10 day intervals. Do not apply sulphur when temperatures exceed 27°C.
	Bacterial canker (*Pseudomonas syringae*)	➢ Clean Crop Copper Spray, 6.0 kg	Young shoots or leaves turn black between early spring and early summer, especially during wet, cool weather. Kills young twigs during wet springs. Apply treatment once in October and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Prune out infected twigs. Do not crowd plants — maintain adequate sunlight and good air circulation. Is often found on container plants after poly has been removed from the cold frame in early spring.

TAXUS — yew

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil Taxus weevil (*Otiorhynchus sulcatus*)	➢ *Endosulfan 50 W, 1 kg ➢ *Thiodan 4 E, 1.25–1.75 L ➢ Sevin 50 W, 2.00–3.0 kg	Larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. [**Plate 81**] Infested plants grow slowly or fail to grow and look dry and off-colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent-shaped notches in needle margins at night. [**Plate 80**] They also attack arborvitae, hemlock, azaleas and rhododendrons. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark and branches during the last week of June and early July. Spray in the evening, as adult activity increases about an hour after sunset. Do not use Thiodan on Anderson yew. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety. Entomopathogenic nematodes (Heterohabditis Sytem™, Nemasys H™) are available to help suppress populations of larvae. Nematodes work very well in infested containers, with less success in the field. Nematodes can be applied in late summer/early autumn and in mid-spring to suppress larval populations. See label for complete directions. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. * *Endosulfan and Thiodan are toxic to fish.*
	Fletcher scale (*Lecanium fletcheri*)	➢ Cygon 480 E, 2.5 L ➢ Diazinon 500 EC, 1.25. ➢ DZN 600 EW, 1.25 L ➢ Lagon 480, 2.5 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	The adult is a reddish-brown sphere that appears on branches. [**Plate 82**] Look for black sooty mould and honeydew on the needles. Heavily infested plants look off colour. Treat newly-emerged crawlers in early July when *Yucca filamentosa* is blooming, or in September when the nymphs migrate. Repeat the application in about 10 days.
	Taxus mealybug (*Pseudococcus cuspidatae* or *Dysmicoccus wisteriae*)	➢ Cygon 480 E, 2.5 L ➢ Diazinon 500 EC, 1.5 L ➢ Lagon 480, 2.5 L ➢ Malathion 500 EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L	A slow-moving, white, woolly insect that can completely cover heavily infested branches and trunks with a waxy secretion. Feeding discolours needles and causes excessive needle cast. Attacks all yew species. Use insecticide on bark of small branches and twigs to control nymphs when the *Aesculus hippocastanum* is blooming. [**Plate 83**]

THUJA — eastern white cedar, arborvitae

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cedar leafminer Arborvitae leafminer (*Argyresthia thuiella* and other species)	➢ Cygon 480 E, 2.5 L ➢ Lagon 480, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ DZN 600 EW, 830 mL	Four caterpillar species mine cedar, with *A. thuiella* the most common. Feeding causes branch tips to turn brown. [**Plate 84**] Adult is a small, light grey moth that appears in late June to early July. Prune out infected tips before June to provide some control. To control larvae, spray with Cygon in early May or late August. Use Malathion in June to control moths.
	Black vine weevil	➢ See under *TAXUS*	[**Plate 80 & 81**]
	Fletcher scale	➢ See under *TAXUS*	[**Plate 82**]
	Juniper scale	➢ Diazinon 500 EC, 1.25 L ➢ Malathion 500 EC, 2.5 L ➢ Orthene 75 SP, 1 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	A small, circular, white scale with a yellow centre, it causes juniper and arborvitae needles to turn yellow. [**Plate 31**] Treat crawlers in late June when *Philadelphus* is at full bloom and *Catalpa* are beginning to bloom. Repeat as needed about 10 days later.

THUJA — eastern white cedar, arborvitae (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Spruce spider mite (*Oligonychus ununguis*)	➣ Sniper 50 W, 0.925–1.25 kg ➣ Cygon 480 E, 2.5 L ➣ Lagon 480, 2.5 L ➣ Malathion 500 EC, 1.25 L ➣ Orthene 75 SP, 1.0 kg ➣ Pentac Aquaflow, 400 mL ➣ Pyrate 480 EC, 2.0 L ➣ Vendex, 0.5–1.0 kg	Use Superior oil as a dormant treatment in early spring. On blue spruce, use only wettable powders to prevent foliage discoloration. Avoid Superior oil and Ethion superior oil. Overwintering eggs hatch in late April and early May, when *Amelanchier* and *Acer platanoides* bloom. Prefers older needles as feeding sites. Control young nymphs with chemicals. Apply 2 sprays at 10-day intervals when mites exist in spring or fall. Use miticides alone for maximum effectiveness. To monitor for mites, shake a branch over a white sheet of paper and look for crawling mites. Many predacious mites help control populations. [1] *Minimum re-entry period is 48 hr.*
	Strawberry root weevil (*Otiorhynchus ovatus*)	➣ Ambush 500 EC, 500 mL	Larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish-brown flightless adult is under 6 mm long and resembles the black vine weevil. Hides during the day and feeds at night. These pests have a large host range. Commonly injured plants include white cedar, spruce and juniper. Adults are active in late June and early July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing and girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow and look dry and off-colour. [**Plate 85**] Transplants often die without becoming established. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. Adults play "dead" during daylight hours and feed at night. Ambush is registered for use on seedlings. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety.
	Tarnish plant bug (*Lygus lineolaris*)	➣ Cymbush 250 EC, 280 mL	Green adults are 6 mm long with dark markings. [**Plate 86**] They become active in early spring. Use treatment in conifer seedling nurseries a maximum of 3 times per season. Do not use in greenhouses.
DISEASES	Botrytis	➣ Rovral 50 WP, 1.2–2 kg/ha	During very humid conditions, a fuzzy grey growth develops on infected plant parts. Treat twigs and buds in spring before leaves develop. Treat conifer seedlings at the onset of Botrytis. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Do not crowd plants — maintain adequate sunlight and good air circulation.
	Leaf blight (*Didymascella thujina*)	➣ Copper spray, 4.0 kg ➣ Dithane M-45, 80 WP 2.75–3.5 kg ➣ Manzate 200 DF, 2.75–3.50 kg	Mainly attacks western red cedar (*Thuja plicata*). Apply fungicides at 10–14 day intervals starting at bud break to protect new growth.

TILIA — linden, basswood

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ See under *FAGUS*	
	Cankerworm	➢ Orthene 75 SP, 1.0 kg ➢ See under *MALUS*	[**Plate 38 & 39**]
	Linden looper (*Erannis tiliaria*)	➢ Malathion 500 EC, 2.5 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Sevin 50 W, 2.0–3.0 kg ➢ Sevin 80 S, 1.25–2.0 kg	Bright yellow larvae have rusty-brown heads and 10 wavy black lines down the back. Present from early spring to early summer. Feeds on a wide variety of hardwood leaves. Band specimen trees with sticky trapping materials in late summer. This will trap wingless females as they climb up the trunk to lay their eggs. Treat foliage when infestation first appears.
	Two-spotted spider mite (*Tetranychus urticae*)	➢ Kelthane 187.5 EC, 2.5 L ➢ Pentac Aquaflow, 400 mL ➢ Vendex 50 W, 0.5–1.0 kg	Leaves become stippled or bronzed. Tiny mites have 2 distinct black spots on back and can be found on leaf undersides. Treat leaf bottoms beginning in early June and repeat as needed.
	Gypsy moth	➢ See under *BETULA*	[**Plate 13 & 14**]
	Japanese beetle	➢ See under *ROSA*	[**Plate 74 & 75**]
DISEASES	Canker	➢ See under *CANKER*	
	Verticillium wilt	➢ See under *ACER*	[**Plate 7**]

TSUGA — hemlock

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil Taxus weevil	➢ See under *TAXUS*	[**Plate 80 & 81**]
	Eastern hemlock looper (*Lambdina fiscelleria*)	➢ Foray 48 B, 2.5–3.1 L/ha ➢ Mimic 240 LV, 290 mL/ha ➢ Sumithion 50EC, 0.56 L or split application at 0.35 L	A 30 mm long grayish caterpillar flecked with black dots. [**Plate 87**] Prefers hemlock, balsam fir and white spruce, but will feed on several other coniferous and broadleaf hosts. Apply Mimic to control early instar larvae, allow 3–7 days for larval mortality. A second application of Mimic may be required. Sumithion split application should be 3–6 days apart.
	Tarnish plant bug	➢ See under *THUJA*	[**Plate 86**]
	Botrytis	➢ See under *THUJA*	

ULMUS — elm

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ See under *FAGUS*	Do not use Orthene on American elm.
	Cankerworm	➢ See under *MALUS*	Do not use Orthene on American elm.
	Elm bark beetle: European elm bark beetle (*Scolytus multistriatus*) Native elm bark beetle (*Hylurgopinus rufipes*)	➢ Methoxychlor 240 EC, 80.0 L ➢ Pyrate 480 EC, 10 L	Elm bark beetles are vectors of the Dutch elm disease fungus. The smaller European elm bark beetle feeds in the crotches of small twigs. The native elm bark beetle attacks rough-barked branches and stems, causing distinct gallery formations. [**Plate 88**] Both are small, brownish beetles about 3 mm long. Destroy elms infected with Dutch elm disease before overwintering adult beetles emerge and lay eggs. To control beetles, treat on suitable days in March and April, before leaves appear on trees. Apply a second treatment in late July.
	Elm casebearer (*Coleophora ulmifoliella*)	➢ Malathion 500 EC, 2.5 L ➢ Sevin 50 W, 2.0–3.0 kg	Overwintering larvae feed on emerging leaves. The larvae mine leaves. Heavy infestations cause leaf browning or scorching. All elms are potential hosts. Treat foliage in early June as mines begin to appear.

ULMUS — elm (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	European elm scale (*Gossyparia spuria*)	➢ [1]Sniper 50 W, 2.0–2.5 kg	Overwintering nymphs become active in early spring. Crawlers are covered in white, waxy cottony strands. By June, females can easily be seen by the white margins around the scale. Treat when young crawlers have emerged in early summer. [1] *Minimum re-entry period is 48 hr.*
	Elm leafminer (*Fenusa ulmi*)	➢ Safer's Insecticidal Soap, 1% solution ➢ Sevin XLR PLUS, 2.3–3.5 L	Treat foliage around late May to early June to control larvae as mines first become apparent. For small infestations, mined leaves can be picked off and destroyed.
	Elm leaf beetle (*Pyrrhalta luteola*)	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Methoxychlor 240 EC, 4.0 L ➢ Orthene 75 SP, 1.0 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	The adult beetle is olive-green with a dark stripe on each wing cover. The beetles chew holes in developing leaves, while the black larvae skeletonize the underside. May attack all elm species. Treat upper and lower leaf surfaces when they are about three-quarters expanded. Do not apply Orthene on American elm. * *Endosulfan and Thiodan are toxic to fish.*
	Lecanium scale	➢ Superior oil, 20 L ➢ Ethion superior oil, 20 L ➢ Sevin XLR PLUS, 2.3–3.5 L	Use Superior oil or Ethion superior oil as a dormant treatment in early spring. Use other materials as foliar sprays to control crawlers when *Sambucus canadensis* begins blooming.
	European red mite	➢ See under *SORBUS*	
	Gypsy moth	➢ See under *BETULA*	[**Plate 13**]
DISEASES	Leafhopper	➢ See under *GLEDITSIA*	
	Dutch elm disease (*Ceratocytis ulmi*) (*Ophiostoma ulmi*)	➢ Alamo (see product label for rate)	Often begins as the wilting of large branches. May begin on one side of the tree. Leaves turn yellow and begin to flag or droop. Stripping away bark reveals stained wood. [**Plate 89**] Control elm bark beetles that carry fungus from diseased trees to healthy ones. Diseased/dead materials must be removed to control beetle populations that breed in them. Alamo is trunk-inject unit that introduces fungicide into the plant system. For use by trained arborists or others trained in trunk injection techniques. This product may be effective when used where i) 20% or less of canopy is showing wilt symptoms; ii) infested branches are removed at first sign of wilt; iii) leaves have fully expanded and plant is actively transpiring (June and July). Do not burn wood in year of treatment. See "elm bark beetle".

VIBURNUM — virburnum

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Snowball aphid (*Neoceruraphis viburnicola*)	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4 EC, 1.25–1.75 L ➢ Malathion 500 EC, 1.25 L ➢ Orthene 75 SP, 1.0 kg ➢ Pirimor 50 WP, 500 g ➢ Pyrate 480 EC, 375 mL	Overwinters in *Viburnum opulus* buds. Does not seem to affect other species. Overwintering eggs hatch as buds begin to open in the spring. Feeding causes severe leaf distortion and twists young shoots. Treat foliage when aphids first appear (about mid-May) and repeat as needed. * *Endosulfan and Thiodan are toxic to fish.*
	Viburnum leaf beetle (*Pyrrhalta viburni*)		Adults and larvae of this beetle skeletonize foliage of *Viburnum opulus*, European high bush cranberry and its selections. [**Plate 91**] Eggs overwinter in twigs of last year's growth. [**Plate 92**] Larvae hatch and begin feeding as leaves emerge in the spring. [**Plate 90**] Prune out and destroy terminal shoots (containing eggs) before May 1.
	Downy mildew (*Peronospora viburni*)		Angular lesions appear between leaf veins. Undersides of leaves turn woolly from fungal growth. Plants often defoliate in response to infection. Downy mildew needs moist conditions and cool or warm (not hot) temperatures. Do not crowd plants — maintain adequate sunlight and good air circulation. Avoid overhead irrigation late in the day. Collect and destroy infected plant material.
	Powdery mildew (*Microsphaera sparsa*)	➢ Daconil 2787 F, 2.5 L	Do not crowd plants — maintain adequate sunlight and good air circulation. Overhead watering *during the day* may reduce the spread and development of the disease. Avoid overhead irrigation late in the day. Apply fungicides when symptoms are first noticed, mid-summer. Reapply at 5–10 day intervals.

4. Rodents and Deer

Rodents and deer can cause significant injuries to nursery and landscape plants. Controlling them can be difficult and often requires long term strategies. For additional information, refer to the OMAF Factsheet *Rodent and Deer Control in the Orchard*, Order No. 98-023 and OMAF Publication 10, *Deer Control Practices in Agriculture.*

Vole Control

Voles chew on roots and girdle tree/shrub stems and trunks. They have shorter tails than mice and ears that lay flat against their bodies. There are 2 types of voles — *pine voles* and *meadow voles*. The meadow vole is more common in Ontario.

Voles need shelter, food and protection from predators to survive. You can manage vole populations by eliminating one of these requirements.

In spring and summer, meadow voles feed on grass seeds, herbs and bulbs. In fall and winter, they feed on the bark of woody plants. Pine voles feed underground, mainly on rootlets and strip the bark off larger roots. Meadow voles make shallow runways along the soil surface while pine voles burrow underground.

Vole Control Options

- In the landscape, maintain good weed control for a distance of at least 60 cm from tree trunks and shrub stems.
- In a nursery with cover crops between tree rows, maintain a herbicide strip at least 1.2 m wide at the base of each tree. Mow the cover crop short in late summer, since dense stands provide shelter to the rodents.
- Tree guards should extend about 45 cm up the tree trunk. Anchor guards firmly into the soil, about 8 cm deep. Keep them secure and free from trash.
- Where possible, encourage populations of natural predators such as foxes, snakes, hawks, owls, dogs and cats.
- Use mouse baits (rodenticides) where you have sustained past damage. Begin baiting the field border in September to help prevent vole populations from exploding in autumn.
- Alternate between a zinc phosphide bait and an anticoagulant bait. (See Table 4–1, *Rodenticides*, on page 94.) Multiple applications of zinc phosphide are not recommended, as voles can become bait shy after the first application and continue to avoid bait for 2–4 months.
- Use bait stations to extend the life of the bait and create a safe haven for rodents to feed. Bait stations will also keep poisonous bait out of reach of pets and other non-target animals. Set about 25 stations/hectare (10/acre). (In field production, baits can be broadcasted over infested areas on sunny fall days when no rain is expected.)

Precautions for Handling Poison Baits

It is important to handle poison baits safely.

- The baits listed in Table 4–1 are recommended for use with commercial nursery plantings only.
- Mark all poison bait storage containers POISON.
- Store poison baits away from children, irresponsible persons, pets and livestock.
- Do not inhale zinc phosphide dust or fumes.
- Do not keep baits containing zinc phosphide in a building used by people or animals.
- Reserve all bait mixing and application equipment for that purpose alone.

- Wear rubber or other protective gloves, as you would when handling hazardous insecticides.

- Wash after handling poison baits.

- Keep dogs and cats that are enthusiastic mousers away from the nursery for at least 2–3 days to prevent them from catching dying mice.

- Do not handle dead mice or voles with bare hands.

- Dispose of dead mice and voles away from human and animal contact.

Use Table 4–1 to select a suitable rodenticide for vole and mouse problems. Note that many rodent baits are available in mountable mini blocks and pellets.

TABLE 4–1. Rodenticides

Method of action	Generic name	Trade name
Anticoagulant	brodifacoum	Ratak +
	bromadiolone	Boothill, Hombre
	chlorophacinone	Ground force Rozol
	difethialone	Generation
	diphacinone	Ramik brown Ramik green
Acute poison	zinc phosphide	Many products available

Rabbit Control

Rabbits feed on the bark, twigs and buds of many woody plants. They seem to prefer thinner-barked plants such as fruit trees, crabapple, flowering dogwood, sweetgum, holly, privet, pine, birch and young maple.

Rabbit Control Options

- Fencing may provide control for smaller areas. Use 25 mm wire mesh fencing, staked every 2 m with sturdy posts. Secure the fence bottom in the ground. Rabbits will not burrow under the fence, but will squeeze through any opening they can find. Extend the fence at least 60 cm above the maximum snow level. Individual tree guards may also be used.

- Trap rabbits and remove them from the area.

- Encourage natural predators.

- Shooting rabbits can keep numbers low. Maintain this method of control all year round. Consult with local authorities regarding firearm bylaws and regulations.

- Use rabbit repellents to discourage feeding.

  - The rabbit repellent must have long-lasting adhesive qualities to be effective.
  - Repellants must taste unpleasant to the rabbit.
  - Put repellant on all plant parts that the rabbit can reach. Take into account the height added by deep snow.

- Chemical repellents consist of commercial Thiram-based mixtures (e.g. Skoot) and ammonia fatty acid soaps (e.g. Hinder).

- Mix Thiram with white exterior latex paint for an effective repellent. Combine 400 g Thiram 75WP with 2 L of water. Slowly stir this mixture into 4 L of white exterior latex paint. Do not use oil base paints, which are toxic to trees.

Deer Control

Deer feed on the buds, shoots and leaves of many woody plants. Feeding causes growth set back and poorly shaped plants. For more information on deer control, see OMAF Publication 10, *Deer Control Practices in Agriculture.*

Deer Control Options

- To help keep deer out of production areas, erect fences around those plants that are attractive to deer (e.g,. yew, rosaceous plants). Use wire mesh fencing at least 2.4 m high and support it with sturdy posts. Electric fences may provide some control.

- Where regulated hunting seasons, special hunts and other measures have not satisfactorily reduced deer damage, deer-removal permits may be issued to farmers to cull those deer that are causing significant crop damage. These permits are issued to farmers, or their agents, only after several conditions have been satisfied. Farmers wishing to obtain a deer-removal permit must first request a damage evaluation report from the Ministry of Natural Resources or OMAF. *These permits are a last resort.*

- Repellents are not very effective against deer browsing. Reapply during the winter months. Thoroughly applied repellents may be successful when alternate food sources exist. When food is scarce, repellents may not work.

- Chemical repellents consist of commercial Thiram-based mixtures (e.g. Skoot) and ammonia fatty acid soaps (e.g. Hinder). Replace these taste repellents every 3–4 weeks. Apply when no rain is forecast for 24 hr. and temperatures range between 4–27°C. Apply to all susceptible plant parts. Spray outer portions of trees and shrubs to a height of 2 m.

- Odorous repellents may discourage deer from feeding. Odorous repellents include bloodmeal, moth flakes, perfumed soaps and human hair.

  - Some research shows that soap bars hanging in the field discourage deer. Drill a hole in each bar of soap, leaving the wrapper in place. You can use small soap bars (e.g. those available from hotels). Any brand of soap works. Hang the soap from a branch about 75 cm above the ground using a twist tie or string. Each bar of soap will protect a radius of about 1 m.

  - Bags of human hair may deter deer, though this has inconsistent results. Place 2 handfuls of human hair in some nylon stocking or a fine mesh bag. Hang the bags on outer tree branches or from the perimeter of the area that you want to protect. Place the bags up to 90 cm apart and 75 cm above the ground. Keep the bags in place from mid-fall to early spring, replacing them monthly.

5. Managing Weeds

A weed management program combines cultural, mechanical and chemical methods appropriate to your situation. Effective weed management depends on weather conditions, soil type and the cropping history on your farm. Before doing anything else, you need to identify your problem weeds and learn about their growth habits. See OMAF Publication 505, *Ontario Weeds* for help in identifying weeds.

Once you know your weeds, minimize potential problems before planting. Eliminate possible weed sources and prevent weeds from establishing.

Weed Control Principles

- You can avoid many weed problems by using weed-free crop seeds and transplants, and by preventing weeds from going to seed. Monitor weed growth in both crop and surrounding non-crop areas.

- Soil conditions that enhance microbial activity are a strong defense against weeds. Practices that increase soil biological activity (i.e., bacteria, fungi, earth worms, insects) can reduce weed problems. Biological activity can increase crop vigour while making weed seeds decay faster in the soil.

Reducing Weeds Before Planting

Cover Crops for Weed Suppression

If you remove a nursery field from production, plant a cover crop or green manure crop before replanting the field.

- Plowdown crops such as rye, red clover, buckwheat, sudan grass, millet and oilseed radish are typical cover crops.

- Cover crops suppress weed growth through crop competition and allelopathy (exuding chemicals to prevent weed seed germination).

- Cover crops also reduce wind erosion of the soil and their residues increase soil organic matter. Improved soil tilth is quite evident in the first crop after a cover crop.

Controlling Perennial Weeds

Many perennial weeds can present problems for nursery crops including quack grass, bindweed, vetch, wild grape, perennial nightshade, thistles, ground ivy, burdock, horsetail, toadflax, milkweed, asters, nut sedge, willowherb and goldenrod.

- Always attempt to minimize (or eliminate) perennial weeds in the preplanting year.

- If necessary, apply a systemic herbicide, like ROUNDUP, to perennial weeds in the preplanting year. Follow directions on the product label and always use the recommended application rate for the weed in question. You must apply herbicides at the proper stage of weed growth (e.g. just before bloom for most perennial broadleaf weeds) to achieve permanent control.

- It can be difficult to control perennial weeds among established plantings because of crop sensitivity to some herbicides and the inability to clean cultivate in established nurseries.

- Repeated cultivation controls some perennial weeds, such as bindweed. Clean the cultivator of weed debris before entering weed-free soils.

- Use non-selective herbicides (such as GRAMOXONE and ROUNDUP) before planting a green manure crop and before plowing it under. Short-residual herbicides such as 2,4-D may be used with tolerant green manure crops. However, avoid herbicides that leave a soil residue in the planting year (e.g. SIMAZINE).

Crop Rotation

Crop rotation is important to any long-term weed control strategy.

- After plowing a cover crop, it is best to replant the field with different nursery stock. For example, if you previously grew conifers, plant deciduous stock. This permits a change in tillage methods, row widths, harvesting and herbicide selection.
- Crop rotation helps break weed cycles and minimizes weed population increases. Short rotations using several crops will increase the yield and profit of individual crops. You can improve weed control by choosing a crop that competes well with the problem weeds.

Stale Seedbeds

The stale seedbed technique involves preparing seed beds early in the growing season.

- Allow weeds to germinate.
- Several weeks later control the weeds using glyphosate or paraquat.
- Once weeds die, seed or transplant the crop into the bed, disturbing the soil as little as possible.

Preparing Container Beds

- Prepare container bed areas with a gravel layer and/or ground coverings (e.g., plastic, opaque woven materials). These surface coverings must exclude light to prevent weed-seed germination. You can reuse the ground coverings for several years before replacing them.
- Keep container beds and roadways weed-free by physical removal or chemical mowing.
- Remove all pulled weeds and discard them well away from the growing area. Do not allow seeds into nearby containers.
- Remove existing weeds from container stock before they flower. Flowering weeds can disseminate hundreds of seeds by wind or by catapulting the seeds.
- Many container weed species have several generations per year since their seeds do not need to overwinter before germinating.
- Every fall, thoroughly remove weeds from container stock so they do not overwinter in the protected environment of the polyhouse. Be sure to remove the rosettes of winter annuals such as shepherd's purse and Canada fleabane. Also remove the established plants and seedlings of common and mouse-eared chickweed. If not removed, these plants will flower by May or earlier.

Eliminating Weed Sources

You can eliminate weed sources using mechanical, cultural and/or chemical weed control measures.

- Control seed escapes with cultural removal or chemical mowing before the weeds set seed.
- Prevent weeds from setting seed in adjacent non-cropped areas.
- Mow at regular intervals to prevent weeds from flowering.
- Use string trimmers in appropriate areas, such as along fences.
- Find the source of weeds that disseminate into the field or container yard. These include poplars, willows, willowherb and Canada fleabane.
- Control weeds around irrigation ponds to avoid sowing small-seeded weeds into container stock with each watering.
- A thick grass cover will help reduce weeds while stabilizing the bank.
- A filtering system in the irrigation line removes weed seeds.

Mechanical Weed Control

Mechanical weed control methods can reduce weeds and weed sources.

- Plant only weed-free seedlings and transplants.
- Do not bring weeds from one field to another. Keep equipment free from weed debris when moving it between fields. Cultivate weedy fields last.

Rotary Hoes

Rotary hoes have fingers that lift and mix the soil, uprooting small weeds.

- Rotary hoes tend to damage crops less than harrows.
- Rotary hoes break up soil crusts and incorporate surface-applied herbicides into the soil. This activates the chemicals and improves the weed control.
- Use rotary hoes during late-morning or afternoon hours. Crop plants are more pliable at these times, reducing injuries and the hot sun can dry out the uprooted weeds.
- For good results, maintain sufficient speed (generally 10–20 km/hr). Cultivating at slow speeds will not be forceful enough to lift weeds out of the ground and may cause more crop damage.
- On light soils or in loose soil conditions, keep rotary hoes working shallow.

Inter-Row Cultivation

Inter-row cultivation or scuffling of row crops uproots small weeds and cuts off larger ones.

- Many kinds of equipment can perform this task.
- When using shovels, allow 50% overlap for thorough weed control. Keep the cultivation shallow and use shields to protect small crops.
- The first cultivation is crucial, since weeds escaping this pass usually grow to maturity.
- Row cultivation works well alongside herbicide applications. Shallow cultivation (2.5–5.0 cm) avoids disturbing any herbicides applied.

Mowing

Mowing and cutting help to control weeds.

- Mow perennial weeds at the bud stage, when root reserves are low and seeds have not set.
- If you plan to apply a herbicide later in the season, allow sufficient time for weed regrowth after mowing.

Managing Herbicide Resistance

Over 120 herbicide-resistant weed species exist throughout the world. See www.gov.on.ca/OMAF/english/crops/facts/01–023.htm# for a list of weeds that show resistance in Ontario. Herbicides must be treated as a resource to preserve. Strategies for preventing resistance follow from there.

Delaying Herbicide Resistance

Repeated herbicide spraying tends to create resistant weeds. Resistance develops at different rates with different herbicides, weed species and weed populations. To minimize resistant weeds in your nursery, follow these steps:

1. *Identify and monitor weeds*
   Resistant weeds look exactly like susceptible weeds. "Escapes" are common after herbicide applications. It can take 10%–30% of a weed population to become resistant before the issue is noticed. Survey your fields regularly and apply diagnostic methods to catch problems as they arise.

2. *Prevent weed spread*
   Clean all implements when leaving a field and never allow resistant weeds to go to seed.

3. *Use alternatives to chemical controls*
   Use mechanical weed controls, such as rotary hoeing or cultivation, wherever possible.

4. *Rotate crops and herbicides*
   Do not use the same herbicides every year. Rotate crops and spray the new crop with herbicides from a different group (i.e. different mode of action) to prevent resistance. Where registered, use tank or formulated mixtures with multiple active ingredients that kill the same weed in different ways.

5. *Keep records*
   Keep accurate crop rotation and herbicide usage records for all of your fields. Long term weed control planning is easier with good records.

6. *Communicate*
   Consult with farmer organizations, universities, extension specialists, agribusinesses, friends and neighbours about herbicide resistance problems. Inform the provincial weed inspector or industry contacts of any resistance you encounter so they can act to prevent weed spread.

7. *Diagnose*

   Weeds that survive a herbicide application may not be resistant. It is important to rule out other factors that can affect herbicide performance. Examples include misapplication, unfavourable weather conditions, improper application timing and weed flushes following a non-residual herbicide application. If resistance appears possible, check for the following:
   - Did the product control other weeds listed on the label? Chances are only one weed species will prove herbicide resistant in a given field situation. If several normally susceptible weed species exist, other factors probably caused the lack of weed control.
   - Did the same herbicide(s), from the same group, with the same action site fail in the same field area last year?
   - Did you use the same herbicide(s) from the same group year after year?

   If at least one of these situations applies, your weeds may be resistant to the herbicide.
   - Try controlling the weeds with a herbicide from another group or use appropriate non-chemical weed control methods.
   - Do not let the weeds go to seed.
   - Contact your OMAF Nursery Crop Specialist, herbicide supplier and the appropriate chemical company to develop a comprehensive management program for the problem.

Chemical Weed Control

You may apply selective and non-selective herbicides to control weeds.

- Use selective chemicals to control weeds among crops.

- Use non-selective chemicals to control perennial weeds or on land not in crops (e.g., roadsides, fencerows, areas difficult to cultivate).

Herbicide Licensing Requirements

- You must have an exterminator's license to apply herbicides on property other than your own domestic property.
- Any person operating an extermination business must hold an operator's license.

For further information, contact the Ministry of Environment Licensing Office, 2 St. Clair Ave. 12A Floor, Toronto Ontario, M4V 1L5.

Applying Chemical Herbicides

To successfully control weeds, you must apply the correct quantity of herbicide uniformly over a target area. While you can treat small areas with a garden sprayer or even a watering can, you'll need power equipment for larger areas. Whatever your application method, it is important to wet all weed foliage.

Herbicides are applied as emulsions, solutions or suspensions. The volume to apply per hectare depends on the herbicide used and the crop being treated. Generally, apply low volumes (50–200 L/ha) of postemergent chemicals on emerged weeds. You must apply higher volumes (150–300 L/ha) of preemergent herbicides. Read the herbicide label and manufacturer's recommendations for the correct volume and pressure.

General Precautions

Selective weed control requires precision spraying equipment, expertly used.

Herbicide drift can damage nearby plants. High pressure, small nozzle tips, herbicide dusts and herbicide mists increase the damage risk. Take all possible precautions to prevent any drift from treated areas.

Never apply herbicides in enclosed structures (cold frames or greenhouses) unless the manufacturer specifically recommends this use.

Equipment used with 2,4-D-like chemicals must never be used to spray other solutions on 2,4-D-susceptible crops or garden plants.

To minimize drift, do not apply herbicides using mist or air blast sprayers in agricultural areas of Ontario.

Herbicide Drift

Herbicides can drift away from the intended target, damaging neighbouring plants and crops and impacting the environment. Drift injuries depend on the extent of herbicide escape and the susceptibility of the crops or plants it reaches. High-pressure sprayers and windy conditions increase the danger of drift.

When spraying herbicides, always guard against physical spray drift and vapour drift.

- Physical spray drift occurs when wind carries spray particles away from the intended target areas.

- Vapour drift comes from herbicide evaporation or volatilization. Vapours can escape during application or from droplets deposited on plant or soil surfaces. In addition to causing damage, vaporization reduces herbicide effectiveness.

To minimize drift:

- Do not spray in hot weather, windy weather or when humidity is low.

- Use low pressures, larger nozzles and a larger water volume.

- Since large droplets drift less than small ones, use the largest droplet size that gives the desired coverage and distribution. To choose nozzles that produce large droplets, follow these guidelines:

    - a narrow spray angle nozzle produces large droplets
    - a larger orifice produces larger droplets
    - a lower operating pressure produces larger droplets.

When To Use Herbicides

Apply herbicides when both crop resistance and weed susceptibility are high. The timing depends on the herbicide, the weeds needing control and the crop. Several different terms describe when herbicides may be applied. Unless otherwise stated, these times refer to the crop plant's development stage.

Application Technology

Always take care to apply herbicides correctly. Incorrect application can waste pesticide, compromise control, damage crops (possibly your neighbours') and contaminate the environment. New equipment and control systems can make herbicide application simpler and more precise.

New Technologies

Equipment manufacturers now work closely with the crop protection industry to refine application systems.

- Computerized sprayer controllers and ground speed radar are available. These provide accurate application monitoring and control.

- New developments in application technology include closed injection systems (which separate the herbicide concentrate from the water carrier) and drift reduction using air assists, air injection nozzles and electrostatic methods.

Sprayers for Home Use

Use a 9–14 L knapsack or compressed air garden sprayer on lawns and around the home.

- A nozzle tip producing coarse spray minimizes spray drift.

- Keep spray pressure low — pressures up to 700 kPa are easily obtained. High pressures produce smaller spray droplets that can drift in light winds to susceptible garden plants.

- Use the sprayer for herbicides exclusively.

Field Sprayers

Use boom-type sprayers for field herbicide applications. These sprayers apply herbicide evenly across the width of the boom. To spray fields effectively, always maintain:

- uniform spray pressure
- constant forward speed
- stable boom height (to assure uniform overlap of the nozzle tip patterns)
- an application rate of 55–450 L/ha.

Air Blast or Mist Sprayers

Never use air blast or mist sprayers to apply herbicides. They can cause herbicidal drift damage, far from the target treatment area.

Wiper Applicators for Selective Weed Control

Wiper applicators (e.g., rope-wick, roller applicator) are commonly used with glyphosate (e.g. ROUNDUP). Check product labels for information about using this technique with other herbicides. Labels will list the crops for which wiper application is registered. To use wiper applicators:

- follow manufacturers' directions

- contact enough of the target weed to get herbicidal effectiveness
- keep the applicator above desirable vegetation to avoid crop injury
- maintain a vehicle speed of 4–10 km/hr
- make a second pass, especially in heavy weed infestations or if using a higher vehicle speed
- avoid contact with sucker growth in orchards, vinelands and shelter belts.

Equipment Use and Care

Spraying Speeds

Uniform application rates require a constant forward speed whenever spray nozzles deliver liquid. If a tractor's driving wheels slip on the soil surface, the tractor's speedometer will not indicate a change in forward speed.

- To monitor forward speed despite wheel slippage on hills, use an independent speedometer with a ground driven wheel.

- Install spray monitors and other electronic rate controllers. These automatically correct for tractor speed variations to maintain a constant application rate.

Using Water Correctly

- Mix herbicides with clean water that does not contain debris, sand or mud.

- Never let the water intake screen rest on a pond bottom when filling a sprayer.

- The water intake line near the screen must, by law, have a check valve or backflow device. This prevents water-source contamination when the pump is shut off.

- Do not use a tank-refilling nozzle, volume-booster nozzle or injection pump when refilling sprayer tanks from ponds or streams. These tank-refilling aids may contaminate the water source.

- When using a farm water supply, install a frost-free water hydrant outside the building. Place a backflow valve/siphon on the discharge end of the hydrant.

Agitation

You must return spray solution to the sprayer tank to provide hydraulic agitation within the tank.

- To be effective, the return or bypass line from the pressure regulator must deliver liquid to the tank *bottom.*

- Return 2–14 L per minute to the tank when applying *chemical formulations* in solution.

- Return 14–27 L per minute for each 450 L of tank capacity when spraying wettable powders. The appropriate rate depends on the *wettable powder* concentration and the size of the tank.

- Wettable powders need a special line from the pressure side of the pump (not the pressure regulator) to the tank for adequate hydraulic agitation using a venturi jet or sparge tube. Sparge tubes need more water than venturis to provide the same agitation. You can reduce the flow rate if the sprayer tank has a mechanical agitator.

Preparing a Wettable Powder and Oil or Emulsifiable Concentrate Mix

To prepare a tank mix of wettable powder and an oil or emulsifiable concentrate, follow these steps unless the product label states differently:

1. Fill the sprayer tank with water to the half-full mark.

2. Start the agitator.

3. Add a premixed slurry of wettable powder and water.

4. Agitate for 2–3 minutes before adding more water.

5. Add the oil or emulsifiable concentrate last.

6. Do not over-agitate the mixture. It may become a grease-like mass that settles to the tank bottom. In addition, over-agitation may cause the mixture to foam excessively.

7. After any break from spraying, agitate the tank thoroughly before resuming.

8. Empty the tank completely before refilling to prevent oil buildup in the sprayer.

9. Clean the tank and sprayer with a detergent or solvent immediately after use, then flush thoroughly with clean water.

Pumps

Sprayer pumps must supply adequate capacity, pressure, volume and agitation for the task at hand.

- Use *piston, diaphragm* or *centrifugal* pumps for wettable powder suspensions.

- Use any of the above plus *roller pumps* for liquid herbicide applications.

- Pumps used for wettable powders and flowable formulations should have abrasion-resistant housings.

- Follow the manufacturer's care and storage instructions for optimum pump performance.

- Running a spray pump without water may cause premature wear or damage.

Nozzles

Accurate spray application requires high quality nozzle tips. They must emit a uniform spray pattern at an expected rate. You can purchase *machined orifice* and *moulded orifice* tips made from materials ranging from *brass, stainless steel* and *hardened stainless steel* to nonmetals such as *plastics/polymers* and *ceramics*. Choose an appropriate tip using the guidelines below and examine the tip's spray pattern before each use. Then maintain a stable boom height to assure uniform spray pattern overlap and to prevent missed weeds in the target area.

- All herbicide formulations cause orifice wear, especially *wettable powders*. Replace nozzle tips when they deliver 10% more spray than they did when new.

- Worn nozzle tips spray unevenly and can produce streaks across a field by delivering too much herbicide to a given area.

- Always clean nozzle tips and screens thoroughly. Remove them from the nozzle body and wash with soap, water and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue buildup on the nozzles.

Flat-Fan Nozzle Tips

- Flat-fan nozzle tips work well with boom-type herbicide sprayers. Flat-fan tips may be colour coded for size (i.e. output). Some colour-coded tips have stainless steel, ceramic or plastic/polymer inserts, or are used for specialized applications. Always read manufacturers' labels carefully.

- Set spacings, boom height and pressure as per manufacturer's recommendations. If not otherwise stated, maintain spray pressure at *275 kPa* for standard elliptical-orifice flat-fan tips. (Some flat-fan nozzle tips operate at a reduced pressure of approximately *140 kPa*. These tips reduce the risk of drift.)

- Maintain a full overlap spray pattern by using *110-series* of flat-fan nozzle tips (instead of *80-series* tips) with the same 51 cm spacing and the same height as the 80-series tips. This reduces misses should the boom bounce while traversing rough ground.

- You may obtain special "even spray" nozzle tips for herbicide band applications. The nozzle's tip height, spray angle and orientation to the traveling direction combine to control the sprayed bandwidth. Follow manufacturers' directions closely.

Flooding-Fan Nozzle Tips

- Flooding-fan nozzle tips have a wide spray angle. They can be used closer to the ground and at lower pressures than flat-fan tips. This reduces drift.

- Flooding fan nozzle tips come in brass, plastic/polymers and stainless steel. They cover roughly twice the width as flat-fan nozzle tips. However, they tend to distribute herbicides less evenly than flat-fan tips.

Broadcast Nozzle Tips

- Broadcast nozzle tips cover a very wide swath.

- Use broadcast nozzle tips for lanes and fence rows where you do not need a uniform spray pattern.

- Never use a broadcast-type nozzle tip near a susceptible crop. The spray may drift severely with even a light breeze.

Full and Hollow Cone Nozzle Tips

You can use full or hollow cone nozzle tips to spray the soil surface when the herbicide is incorporated into the soil with a disk harrow, cultivator or similar tillage implement.

Nozzle Screens

You may obtain ball-check and plain nozzle screens. Ball-check screens use a diaphragm check valve on each nozzle to minimize dripping from the boom.

- Never mix screen types in a spray boom, since different screen types produce different flow rates through the nozzle.

- Always clean nozzle screens thoroughly. Using protective gloves, remove them from the nozzle body and wash with soap, water and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue buildup on the nozzle screens.

Cleaning the Sprayer

- Clean sprayers immediately after spraying each day *and* whenever you change chemicals. Delaying even overnight allows persistent deposits to form.

- Do not neglect any sprayer parts. Clean the spray tank, booms, hoses, nozzles, tips, screens, filters, strainers and pumps. Be sure to remove every trace of herbicide.

- Cleaning techniques depend on the herbicides applied. Many herbicides list tank-cleaning information on the label — always follow these instructions. If necessary, contact the pesticide manufacturer to learn the best cleaning methods for a product. If you can not get specific cleaning instructions, use a strong detergent or alkaline cleaner. Then rinse thoroughly.

- *Surfactants* may remove pesticide residues from spray equipment. Be sure tanks containing herbicide/surfactant (e.g. *Agral 90*) mixtures are scrupulously clean. Otherwise, the mixture may remove residues from the spray equipment, adversely affecting the crop.

Environmental Issues when Cleaning

- Before cleaning the sprayer, you must dispose any surplus tank mix safely. The *Grower Pesticide Safety Course* suggests diluting the remaining spray solution at least 1:10 with water. You can safely apply this diluted solution to the previously treated area if you do not exceed the maximum application rate on the product label.

- Equipment used with phenoxy herbicides (e.g., 2,4-D, MCPA) must never be used to spray other types of solutions on phenoxy-susceptible crops or garden plants. Never store these products near green houses or other areas with susceptible crops.

- The wash water contains herbicide. Never allow wash water into a well, lake, pond, river or other water source.

- For more information, see application technology on the OMAF Web site at www.gov.on.ca/OMAF/english/crops.

Sprayer Calibration

Calibrate sprayers frequently, especially when spraying wettable powders. Wettable powders erode the nozzle opening. As a nozzle wears, the quantity of herbicide delivered increases and distribution becomes uneven.

Determining Application Rates in L/ha

There are many ways to calibrate a sprayer or determine the amount herbicide applied to one hectare of land. One of the following 2 methods is recommended:

Method 1:

This method uses a graduated cylinder calibrated in millilitres. See OMAF's Web site at www.gov.on.ca/OMAF/english/crops/sprayer/ep75.htm for more detailed instructions.

1. Set 2 stakes 50 m (164 ft) apart in the field or along a fencerow beside the field.

2. Select the tractor gear and throttle setting you will use while spraying. With the sprayer half full of water, do a test run to determine how many seconds it takes to travel the 50 m course. Repeat the trial at least 3 times to get an average time. Avoid previous wheel tracks in the field.

3. Mark or note the throttle setting and/or rpm's on the tachometer. Do not change the throttle setting when stopping for next step.

4. Operate the sprayer while stationary. Use the desired pressure and the same throttle setting or rpm's used in the test runs. Spray for the length of time it took to travel 50 m. Collect the spray from each nozzle in a graduated cylinder (in millilitres).

5. Average the output per nozzle in millilitres. Clean or replace any nozzle more than 5% outside of the average nozzle output. Then reinstall all cleaned/new nozzles and recalibrate.

6. Measure the boom's nozzle spacing in metres.

7. Check the calibration rate in the field using herbicide solution in the sprayer. The type or quantity of herbicide in the tank may produce a different flow rate than plain water.

$$\textbf{Application rate} = \frac{\text{(mL liquid per nozzle) x (0.2)}}{\text{nozzle spacing (m)}}$$

Conversion factors:

L/ha x 0.4 =L/acre

L/ha x 0.11 = U.S. gal/acre

L/ha x 0.09 =Imp. gal/acre

Sample Calculation:

Time to travel 50 metres:	24.5 seconds
Liquid collected/nozzle for 24 seconds:	525 mL
Nozzle spacing on the boom:	0.5 metres

$$\textbf{Application Rate} = \frac{525\ \text{mL} \times 0.2}{0.5\ \text{m}} = 210\ \text{L/ha}$$

Conversions:

210 L/ha x 0.4 = 84 L/acre

210 L/ha x 0.11 = 23 U.S. gal/acre

210 L/ha x 0.09 = 18.9 Imp. gal/acre

Method 2:

1. Set 2 stakes 200 m (656 ft) apart in the field. Do not use a different distance. A different distance will not work, as this method divides the number of square metres in one hectare by the distance traveled as follows:

$$\frac{10{,}000\ \text{m}^2}{200\ \text{m}} = 50$$

2. Add enough clean water to the sprayer to make the following precalibration adjustments.

3. Adjust the boom height to obtain the sprayer manufacturer's recommended overlap for the nozzle tips and nozzle spacing used. For example, the boom should be 53–58 cm above the surface to be sprayed with a spray angle of 65°. For a spray angle of 80°, the height should be 42–48 cm above the target surface.

4. Operate the sprayer. Adjust the bypass relief valve to give the desired pressure with the nozzles operating. This also ensures that the sprayer lines are filled with water.

5. Fill the tank and place it on a level surface. Then record the water level on the tank's sight gauge or with a measuring stick.

6. Spray between the stakes in one direction, maintaining a set speed and pressure. Turn the boom "on" as you pass the first stake and "off" as you pass the second. Mark the throttle setting.

7. Return the sprayer to the same level location as before the calibration run. Carefully measuring the added water, refill the tank to the original mark on the sight gauge or measuring stick.

8. Calculate the application rate in litres per hectare using this formula:

$$\textbf{litres / hectare} = \frac{\textbf{litres of water added x 50}}{\textbf{swath width in metres}}$$

Sample Calibration Calculations

Broadcast Spraying

If the sprayer's swath width is 6.5 m and you need 30 L of water to refill the tank, the application rate in litres per hectare is:

$$\frac{30 \times 50}{6.5} = 231\ \text{L/ha}$$

Band Spraying

With band spraying, acreage sprayed is not the same as crop acreage. The herbicide rates given in this publication apply to the area actually sprayed.

If the sprayer has 10 nozzles and each nozzle covers a 36 cm (0.36 m) band, the swath width is:

10 x 0.36 or 3.6 m

If you need 10 L of water to refill the tank, the application rate in L/ha is:

$$\frac{10 \times 50}{3.6} = 139 \text{ L/ha}$$

Determining the Number of Hectares per Tankful

Once you calibrate the sprayer, determine the number of hectares you can spray with a full tank as follows:

$$\frac{\text{tank capacity in litres}}{\text{L/ha}} = \text{ha/ tank}$$

For example:

$$\frac{\text{450 litre tank}}{\text{110 L/ha}} = \text{4.1 ha / tank}$$

If your tank is marked in Imperial gallons, convert to litres:

imperial gallons x 4.5 = L

80 imperial gallons x 4.5 = 360 L

If your tank is marked in U.S. gallons, convert to litres:

U.S. gallon x 3.8 = L

100 U.S. gallons x 3.8 = 380 L

Calibrating Hand-Held and Backpack Sprayers

Many people use small hand-held or backpack sprayers to treat problem areas or spray areas that were missed. Like your field sprayer, small sprayers must be calibrated accurately.

Method 1:

1. Set 2 stakes 50 m (164 ft) apart in the field.
2. Fill the sprayer ½ full with water.
3. Walk the 50 m course 3 times at a uniform pace. Calculate your average time to travel the course.
4. Measure the width (in metres) of the band sprayed by the nozzle at your walking pace.
5. Pump the sprayer, collecting liquid from the nozzle into a measuring device for average time noted in step 3.
6. Determine the application rate:

$$\text{litres / ha} = \frac{\text{mL liquid / nozzle} \times 0.2}{\text{Band width in metres}}$$

Method 2:

1. Partially fill the sprayer. Pump to the pressure you will use during the pesticide application.
2. Spray to determine the *swath width* (in metres).
3. Walk at a steady pace for 15 sec. Measure the distance you travel (in metres) during that time.
4. To calculate the *area* (in m^2) sprayed in 15 sec., multiply the *swath width* (determined in step 2) by the *distance travelled* (determined in step 3). This area is **A**.
5. Spray into a measuring device for 15 sec. The amount of solution (in litres) sprayed in 15 sec. is **B**.
6. Determine the application rate

$$\text{litres / ha} = \frac{B \times 1000}{A}$$

Convert any pesticide application rate to the amount needed for a small area as follows:

1 kg/ha = 10 g/100 m^2.

For liquids, 100 L/ha = 1 L/100 m^2

Determining the Herbicide Quantity Required

- The common name (i.e. its active ingredient) of each herbicide listed in this publication appears in lower case letters (e.g., *napropamide, oxidiazon, glyphosate*).

- The product TRADE NAMES appear in caps (e.g., *DEVRINOL, RONSTAR, ROUNDUP*). We state the total substance (e.g., liquid, powder) in the container as supplied by the manufacturer. Its formulation appears in brackets following the trade name.

- Herbicides in this publication are specified by quantity of *active ingredient* (i.e. *common name) per hectare* and by quantity of *product TRADE NAME per hectare.*

- If the specified rate is "product per hectare," simply use that amount.

- Always verify product labels before use to confirm the amount of active ingredient it contains.

Materials, Mixing and Mixtures

Dry Formulations

- Dry herbicide formulations come as granules, soluble powders and wettable powders.

- Granules do not require mixing — simply apply them as is. Many herbicides used for preemergent treatments come in granular formulations. Performance usually equals that of the comparable liquid. Available equipment provides satisfactory distribution.

- Soluble powders should be dissolved in water.

- Wettable powders do not dissolve in water. They form a suspension requiring constant agitation.

Liquid Formulations

- Many liquid herbicide formulations form a solution when mixed with water.

- Oil-based liquid herbicides form an emulsion requiring constant agitation. Emulsions appear milky.

Mixing Herbicide Formulations

- Some herbicides can be combined with other chemicals in a single application. These combinations must be registered. Do not apply herbicide mixtures or herbicides mixed with other pesticides or foliar fertilizers unless the combination is registered for your intended use.

- Before mixing herbicides, consult package labels for compatibility information. Some formulations may react when mixed together, creating materials with new properties and activities.

- When using multiple herbicides together, mix one with the appropriate quantity of water. Then add the second. This reduces the formation of gums and precipitates that might clog nozzles and filters.

- Where water has a high salt content, test water/ chemical compatibility before spraying. Use the mixture at field strength in a small area and monitor the results.

- Do not use surfactants or detergents in spray solutions unless specifically recommended by the herbicide manufacturer or this publication.

Application Indicators

You may obtain *colourants* and *foam markers* from agricultural chemical dealers. These indicators make accurate applications easier.

- Foam marking systems help the applicator minimize overlap.

- Colourants added to a pesticide solution make the applied material more visible. For example, colouring a herbicide used on cut stumps of woody plants helps assure thorough coverage without respraying; water-soluble colourants make lawn spraying easier. Available colourants include:

  Bullsey Basal 55 blue, oil soluble
  Blazon blue, water-soluble
  Bas-oil Red, oil soluble

TABLE 5–1. Herbicides Registered For Nursery Crops in Ontario (by Trade Name)

Trade Name	Common Name
BASAMID	dazomet
BONANZA	trifluralin
CASORON	dicholbenil
CIPC	chloropropham
DEVRINOL	napropamide
DUAL MAGNUM	s-metolachlor
EXPEDITE GRASS & WEED KILLER	glyphosate
GRAMOXONE	paraquat
KERB	propyzamide
PRINCEP NINE-T	simazine
RIVAL	trifluralin
RONSTAR	oxadiazon
ROUNDUP	glyphosate
SIMADEX	simazine
SIMAZINE	simazine
TERR-O-GAS	methyl bromide/ chloropicrin
TOUCHDOWN	glyphosate
TREFLAN	trifluralin
VAPAM	metam sodium
VENTURE L	fluazifop-p-butyl
VORLEX PLUS	methyl isothiocyanate/ dichloropropene
VORLEX PLUS CP	methyl isothiocyanate/ dichloropropene/ chloropicrin

A Compendium of Herbicides with their Recommended Uses in Ontario — 2003

Products appear alphabetically by common name below. Trade names listed under each common name appear alphabetically. All listed products are registered for the listed purpose. The order in which products appear does not constitute a preference ranking.

TABLE 5–2. Herbicides Registered In Ontario (by Common Name)

Common Name	Trade Name
chloropropham	CIPC
dazomet	BASAMID
dicholbenil	CASORON
fluazifop-p-butyl	VENTURE L
glyphosate	EXPEDITE GRASS & WEED KILLER ROUNDUP TOUCHDOWN
metam sodium	VAPAM
methyl bromide/chloropicrin	TERR-O-GAS
methyl isothiocyanate/ dichloropropene	VORLEX PLUS
methyl isothiocyanate/ dichloropropene/chloropicrin	VORLEX PLUS CP
napropamide	DEVRINOL
oxadiazon	RONSTAR
paraquat	GRAMOXONE
propyzamide	KERB
s-metolachlor	DUAL MAGNUM
simazine	PRINCEP NINE-T SIMADEX
trifluralin	BONANZA RIVAL TREFLAN

Preplanting Treatments

Some preplant herbicides act on germinating seedlings, while others also kill weed seeds.

- Apply preplant herbicide treatments before you sow or plant.

- You must incorporate some preplanting materials into the soil soon after application. We provide incorporation instructions when these herbicides are recommended.

Soil Fumigants

Fumigants generally control nematodes and soil diseases. They can control weeds at higher application rates.

- Before applying fumigants for nematode control, analyze your field soil's nematode count. See the Appendix in this guide for sampling instructions. Ensure that nematodes are the problem before using chemicals.
- Carefully follow the fumigant manufacturer's directions for dosage and methods of use.
- Wear a suitable respirator and full protective gear when using fumigants. Telone, Vapam, Vorlex and methyl bromide are extremely toxic to the applicator. See Chapter 1, *Using Pesticides Safely*, for safety details.

To use preplant fumigants effectively:

- Fumigate in the fall when soil temperatures are above 4°C. Fumigant dispersal improves at warmer soil temperatures (above 15°C).
- Remove trash and old root systems.
- Work the soil to a depth of 25–30 cm. Tilth and moisture should be in good seedbed condition.
- Inject the fumigant about 30–40 cm deep.
- Pack or water immediately after injection to seal the soil surface.
- Ideally, leave the soil undisturbed until spring. Delay necessary fall planting until at least one week after the fumigant injection. Colder soils (below 15°C) require longer periods from injection to aeration.
- Work and aerate the soil for about a week before planting. For fall planting, aerate the soil for at least 2 weeks after working.
- Fall ryegrass has been recently linked with high populations of root lesion nematodes. Try using non-traditional types of annual cover crops such as pearl millet and sorghum. Use Italian ryegrass as an annual cover crop — it is a poor host for root lesion nematode.

Common Name: dazomet

Trade Name: BASAMID

Chemical Family: Dithiocarbamate

Rates of Application:

dazomet	500.0 kg/ha
BASAMID (98Gr)	510.0 kg/ha

Sensitive Weeds:
Most germinating weed seeds.

Uptake and Translocation:
Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.

Basis of Selectivity:
Non-selective. Chemical must dissipate completely from the seedbed before planting or injury may occur.

Application Methods:
Apply granular product to a well-worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing the edges. After waiting 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6°C. Refer to manufacturer's directions for specific details and directions on sealing soil, evacuating gases and performing the safety germination test.

Residual Activity:
Depends on the rate applied, soil moisture and soil temperature. The gases are toxic to all growing plants. Perform a safety germination test before planting.

Unique Characteristics:
Also controls unencysted nematodes and soil fungi.

Manufacturer: ***BASF Canada***

Common Name: metam sodium

Trade Name: VAPAM

Chemical Family: Thiocarbamate

Rates of Application:

metam sodium	1250.0 kg/ha
VAPAM (380 g/L)	3287.5 L/ha

Remarks:
Field replant sites of ornamentals and forest tree stock.

Sensitive Weeds:
Most scarified weed seeds and freshly vegetative parts, including rhizomes and germinating seedlings.

Basis of Selectivity:
Most plant parts are sensitive. Do not plant crops until all fumigant dissipates from the soil. With moisture, it releases methyl isothiocyanate gas. This kills most scarified seeds and fleshy vegetative parts (including rhizomes and germinating seedlings).

Application Methods:
Apply as a drench to soil, wet at least 8 cm deep. Apply uniformly using injectors, water or other incorporation tools that carry the product to the desired depth. May be applied via the irrigation system. No gas-proof cover needed except for very porous soil. Apply water via sprinklers to provide a surface water seal. Do not plant for 10–14 days (or longer if the weather is cool). All traces of toxic gas must dissipate from the treated soil before planting to prevent plant injury.

Residual Activity:
10–40 days, depending on soil temperature and the amount of organic matter in the soil. Greatest persistence at low temperatures and with high organic matter levels. Plant 12–16 days after treatment following a lettuce seedling bioassay that indicates no injury.

Unique Characteristics:
Also controls nematodes, soil fungi and soil insects.

Manufacturer: ***Amvac Chemical Corp.***

Common Name: methyl bromide / chloropicrin

Trade Name: TERR-O-GAS 67

Chemical Family: Organohalogen

Remarks:
Methyl bromide is very poisonous to humans and live stock. Only experienced, licensed operators may use it.

Sensitive Weeds:
Gas is toxic to germinating seedlings.

Application Methods:
Formulated as a pressurized liquid which, when released from its container, forms a gas. Product must be applied under a gas proof cover, usually plastic. Soil must be sealed with a plastic sheet since the gas is highly volatile. Refer to the label for detailed directions.

Methyl bromide gas is very volatile, and highly poisonous to humans and livestock. Inhalation, ingestion and dermal contact may absorb it. You must obtain a permit from the Ontario Ministry of the Environment each time it is used.

The seedbed or greenhouse must be aired completely after the treatment period. If there is any question, study the safety precautions in the *Pesticides Act* and follow the manufacturer's directions to the letter.

Unique Characteristics:
Also controls soil insects, nematodes and fungal diseases.

Manufacturer: Great Lakes Chemical Corp.

Common Name: methyl isothiocyanate/dichloropropene

Trade Name: VORLEX PLUS, VORLEX PLUS CP

Chemical Family: Thiocarbamate

Rates of Application:

methyl isothiocyanate/ dichloropropene	32.2–258.6 kg/ha
VORLEX PLUS (203 g + 373 g/L)	56–450 L/5.0 L
methyl isothiocyanate/ dichloropropene/chloropicrin	40.2–323.7 kg/ha
VORLEX PLUS CP (185 g + 370 g/L + 163 g/L)	56–450 L/5.0 L

Remarks:
A liquid fumigant injected into a prepared seedbed with special applicators. Chloropicrin adds additional disease control. Preplant treatment in field and greenhouse soils used for ornamentals such as flowers and evergreens.

Sensitive Weeds:
All growing weed seedlings within the fumigated zone. Product may not control non-germinated seeds or established weeds.

Basis of Selectivity:
Non-selective. Gas is toxic to most young, green plant tissues.

Application Methods:
Injected 15–20 cm into the soil using special equipment. Seal the soil by surface irrigation or by physically compacting the surface. Cultivate the fumigated soil after the desired waiting period to dissipate the gas.

Residual Activity:
Varies with soil type — usually 4–6 weeks if left undisturbed. Always check the soil for fumigant using the lettuce germination test before planting a crop.

Unique Characteristics:
Also controls fungal diseases and unencysted nematodes.

Manufacturer: ***Agrevo Canada Inc.***

Preemergence Treatments

Some preeminence treatment chemicals control weeds by killing weed seedlings. Others deposit a toxic chemical layer (in which germinating seeds and young seedlings cannot survive) on or near the soil surface. A herbicide may have either or both effects on a target weed.

- Apply preemergence treatments either after the seedling stage but before the specified weed or crop emerges, or after planting new nursery stock.
- Crops must tolerate the chemical at the seedling state or the chemical's toxicity must have disappeared before the crop emerges.
- Apply to a smooth, well-prepared, clod-free seedbed for best results.
- The surface soil should be moist and the temperature favourable for rapid weed-seed germination.

Common Name: chloropropham

Trade Name: **CIPC, CIPC EC, CIPC GR**

Chemical Family: **Phenylcarbamate**

Rates of Application:

chloropropham	6.8–11.0 kg/ha
CIPC	34.0–55.0 kg/ha

Remarks:
Use with field nursery stock or beds, daffodils, gladioli, iris and tulips.

Sensitive Weeds:
Annual broadleaf and grass weeds including purslane, chickweed, smartweed, carpetweed, false flax, annual bluegrass, crab grass, ryegrass, stink grass and dodder.

Uptake and Translocation:
Readily translocated to leaves following root absorption. Seeds and emerged dodder absorb vapours.

Basis of Selectivity:
Rapid degradation in tolerant plants and from soil adsorption.

Application Methods:
Preemergence and directed postemergence in specified crops. Moist soil required for effective weed control. Use lower application rates on sandy or coarse textured soils, higher rates on clay or muck soils. Soil temperatures below 16°C improve weed control — use lower application rates at low temperatures.

Residual Activity:
Tightly bound to soil colloids. The dissipation rate varies with microbial activity and moisture level. High soil temperature and excessive soil moisture increase the dissipation rate.

Manufacturer: ***Stanchem Inc.***

Common Name: dichlobenil

Trade Name: **CASORON 4G**

Chemical Family: **Benzonitrile**

Rates of Application:

Field applications:	
dichlobenil	4.4–7 kg/ha
CASORON (4 Gr)	110–175 kg/ha
Container applications:	
dichlobenil	4.4 kg/ha
CASORON (4 Gr)	110 kg/ha
Container bed preparation:	
dichlobenil	4.4–7 kg/ha
CASORON (4 Gr)	110–175 kg/ha

Remarks:

Use on field woody nursery stock: eastern white cedar (arborvitae), ash, birch (cutleaf weeping), boxwood, caragana, eastern red cedar, crabapple, elm, euonymus, forsythia, heather, holly (*Ilex* sp, except *I. crenata*, *I. rotunda*, *I. vomitoria*), honeysuckle, juniper, lilac, linden, locust, maple, mockorange, rhododendron, rose, spirea, willow and yew.

Use on some container woody nursery stock: *Juniperuschinensis*, *J. horizontalis* and *Thuja occidentalis* only.

Do not use on: gladiolus, mugo pine, fir (*Abies* sp), hemlock, ajuga, *Ilex crenata*, *I. rotunda*, *I. vomitoria* or spruce.

Do not use on: herbaceous perennials (all plants which die down to the ground in the fall).

Use cautiously on: shallow rooted ground covers (euonymus can be treated with this product).

Sensitive Weeds:

Most weeds are susceptible to, or suppressed by, dichlobenil including perennials, vetch and horsetail.

Uptake and Translocation:

Absorbed by roots and rapidly translocated upward in the plant.

Basis of Selectivity:

Selectivity based on physical separation between the dichlobenil vapour layer in the top 5 cm of soil and the established crop roots below this level.

Application Methods:

Applied as a preemergence treatment to susceptible weeds, preferably in the fall or early spring.

Container nursery stock: Use only on containers growing outside. Apply at least 4 weeks after planting into containers with a weed free surface. Do not use after Sept. 15 or within 30 days of placing treated stock in overwintering structures.

Container bed preparation: Apply to bare soil before putting container pots onto the bed. For best results, apply to soils containing more than 2% organic matter. Inconsistent weed control on gravel or sandy soils. Apply in spring on a cool day and incorporate immediately using irrigation or mechanical methods. Do not cover polyhouses with plastic for 1 month after application. Do not apply in plastic-covered polyhouses or greenhouses. Do not transplant into treated soils for 1 year.

Residual Activity:

May persist and provide weed control for 2–6 months. Higher rates and applications following use in previous years may cause soil residues to persist for more than 1 year.

Unique Characteristics:

Although applied as a granular herbicide, it kills with a vapour layer in the topsoil profile. Weed roots take up herbicide when entering this zone. Do not apply to very warm soils, since high temperatures volatilize the herbicide and prevent weed control.

Manufacturer: ***Uniroyal Chemical***

Common Name: napropamide

Trade Name:
DEVRINOL 2G
DEVRINOL 10G,
DEVRINOL 50 DF,
DEVRINOL 50 WP

Chemical Family: **Amide**

Rates of Application:

napropamide	4.5 kg/ha
DEVRINOL 2G	225 kg/ha
DEVRINOL 10G (10 Gr)	45 kg/ha
DEVRINOL 50DF (50 DF)	9 kg/ha
DEVRINOL 50W (50WP)	9 kg/ha

DEVRINOL can be tank mixed with SIMAZINE 80 W, napropamide (4.5 kg/ha) plus simazine (1.096 kg/ha)

DEVRINOL DF (50 DF)	9 kg/ha plus
SIMAZINE 80W (80WP)	1.4 kg/ha

Remarks:

Use on: newly-transplanted or established ornamentals, woody nursery stock, forest tree stock and container-grown ornamentals. DO NOT apply to species right after direct seeding.

Use on all of the following field-grown nursery stock:
Deciduous and Evergreen Trees: apple, ash, azalea, birch, black walnut, boxwood, cedar, cherry, cypress, dogwood, Douglas fir, eucalyptus, euonymus, fir, firethorn, hawthorn, hemlock, honeylocust, hibiscus, hypericum, holly, Japanese larch, juniper, laburnum, maple, peach, pear, pin oak, pine, plum, poplar, privet, rhododendron, rose, spruce and yew

Deciduous and Evergreen Shrubs: abelia, aucuba, azalea, bottlebrush, camellia, cotoneaster, crape myrtle, dogwood, forsythia, honeysuckle, leucothoe, nandina, osmanthus, photinia, raphoiolepis, star jasmine and viburnum

Fruit and Nuts: filbert, grape and walnut

Ground covers: ajuga, hedera, hypericum, ivy, lantana, liriope, pachysandra, sedum and vinca

Flowers: aster, dahlia, daisy, geranium, narcissus, osteospermum (African daisy), petunia and hosta

Use on the following container-grown nursery stock:
abelia, ageratum, azalea, bottlebrush, bougainvillea, boxwood, camellia, cedar, cotoneaster, crape myrtle, cypress, dogwood, Douglas fir, eucalyptus, euonymus, English ivy, fir, firethorn, forsythia, gardenia, geranium, heather, hibiscus, holly, juniper, leucothoe, liriope, nandina, pachysandra, photinia, pine, privet, raphoiolepis, rhododendron, rose, sedum, star jasmine and vinca

Sensitive Weeds:

Many annual weeds including crab grass, barnyard grass, annual bluegrass, foxtail, sandbur, wild oats, goose grass, chickweed, groundsel, redroot pigweed, lamb's quarters, purslane, prostrate knotweed, pineappleweed and prickly lettuce.

Uptake and Translocation:

Absorbed through the roots of germinating weeds. Translocated upward through seedlings.

Basis of Selectivity:

Metabolized by tolerant species. Inhibits root growth of germinating seedlings. Does not affect established plants due to placement selectivity.

Application Methods:

Field nursery stock: Apply herbicide preplant using water as the carrier. Incorporate uniformly to 2.5–5 cm depth, using irrigation or mechanical methods (e.g., tandem discs, field cultivator with sweep teeth). Follow with a leveling device.

Apply on established crops to a weed free soil surface. Irrigate unless there is adequate rainfall within 7 days after spring/fall application or within 2 days after summer application. Soil must be wet to a depth of 5–10 cm.

Container nursery stock: Apply at any time of the year to a weed-free media surface. May be used on newly-planted container stock once potting media settles after first watering. Incorporate by watering within 7 days after a spring or fall application. Water within 2 days after a summer application. *Does not control bittercress.*

Residual Activity:

Provides season long weed control if properly incorporated. Deep plowing minimizes carryover effects.

Unique Characteristics:

Does not control germinated weeds. Resists leaching. Do not plant crops not registered for product use for 12 months after a napropamide application to avoid injury.

Manufacturer: ***United Agri Products***

Common Name: oxadiazon

Trade Name: **RONSTAR 2G**

Chemical Family: **Oxadiazole**

Rates of Application:

oxadiazon	2–4.5 kg/ha
RONSTAR 2G (2 Gr)	100–225 kg/ha

Remarks:

Use in container nursery stock on: vine maple, dogwood, emerald and gold euonymus, juniper, mugo pine, scotch pine, potentilla, Colorado spruce, Serbian spruce, Nanking cherry, alpine currant, golden elder and lilac

The following plants are sensitive to RONSTAR 2G:
Andromeda Snowdrift, Temple Bell; *Cotoneaster* Eichholz, Himalayan, Shangri-la; *Calluna* spring heath Mediterranea pink; *Hibiscus* Red Heart; *Picea abies* Primila, Norway spruce Primila; *Picea glauca* Densena, Densena white spruce; *Rhododendron* Azaleas Pink Champagne, Hershey, Leuchtenfuer, Memoire, John Hearrens, Himo-Crimson, White Grandeur, Everest, Girard Roberta, Rhododendron Daphnoides, Nova Zimbela; *Tsuga canadensis* Pendula, weeping hemlock; *Viburum davidii*, David viburnum

Sensitive Weeds:

Annual weeds including stinkweed, bittercress, common groundsel, lamb's-quarters, purslane, black nightshade, pigweed, redroot, tumble, shepherd's-purse, annual bluegrass, barnyard grass, green and yellow foxtail, and crab grass.

Uptake and Translocation:

Primarily through emerging shoots when they penetrate through the treated soil layer.

Basis of Selectivity:

Greater physiological tolerance relative to susceptible species and lack of contact with sensitive crop tissue.

Application Method:

Use on newly-transplanted and established ornamentals and trees. Apply uniformly to soil. Apply at any time of the year before weed seeds germinate. Remove existing weed growth for satisfactory weed control. *Do not apply* to wet foliage or when granules can collect on leaves. Apply the herbicide at least 4 weeks before covering poly houses in the fall.

Residual Activity:

60–120 days

Unique Characteristics:

Moisture activates the chemical — rainfall or overhead irrigation after application improves weed control. When applied to soil, product is rapidly and strongly fixed by soil colloids. Due to low water solubility and this adsorption, downward and lateral movement is limited under the influence of rain or irrigation.

Manufacturer: Aventis CropScience Canada Co.

Common Name: propyzamide

Trade Name: **KERB**

Chemical Family: **Amide**

Rates of Application:

propyzamide	1.5 kg/ha
KERB (50WG)	3 kg/ha

Remarks:

Use on coniferous trees and shrubs, established iris, peony and ground covers. Do not use on *Vinca minor.*

Sensitive Weeds:

Perennial grasses including quack grass, annual grasses, volunteer cereals and common chickweed.

Uptake And Translocation:

Taken up by plant roots and translocated to foliage. Little foliar absorption.

Basis of Selectivity:

Faster degradation in tolerant species.

Application Methods:

Preemergence to annual weeds. Postemergence control of perennial grasses when applied in the fall. Apply from late September to November when soil temperature is low but above freezing and soil moisture is high.

Residual Activity:

Persists 2–9 months, depending on soil type and climate. Decomposes slowly at temperatures under 1°C, but accelerates at temperatures above this level. Greatest persistence in sandy soils with low organic matter.

Unique Characteristics:

Rainfall or irrigation required after application. This moves herbicide into the root zone for uptake by perennial grasses and germinating annual grasses.

Manufacturer: Dow AgroSciences Canada Inc.

Common Name: simazine

Trade Name: PRINCEP NINE-T, SIMADEX, SIMAZINE, SIMAZINE 480

Chemical Family: S-triazine

Rates of Application:

Field applications:	
simazine	2.3–3.4 kg/ha
PRINCEP NINE-T (90WG)	2.5–3.8 kg/ha
simazine	2.2–3.4 kg/ha
SIMAZINE 80W (80WP)	2.8–4.3 kg/ha
simazine	1.8–6.8 kg/ha
SIMADEX (500 g/L)	3.6–13.5 kg/ha
Container applications:	
simazine	2.3 kg/ha
PRINCEP NINE-T (90WG)	2.5 kg/ha
SIMAZINE 80W (80WP)	2.8 kg/ha/300 L

Remarks:

Use on new or established Christmas tree and woodland plantations (2 years or older white pine and balsam fir). Use *PRINCEP NINE-T* (only) for conifer site preparation before planting fir, pine and spruce.

Use on woody ornamentals and nursery stock established at least 1 year: cedar, barberry, apple, flowering crabapple, boxwood, cotoneaster, dogwood, holly, rose, yews, chamaecyparis, hemlock, juniper, multiflora rose, peony, spruce, mugo pine, black walnut and white ash

Use on container nursery stock: *Juniperus, Thuja* and *Taxus* only

Sensitive Weeds:

Annual broadleaf weeds such as pigweed, lady's-thumb, lamb's-quarters, purslane, ragweed, volunteer clover, wild buckwheat, smartweed, plantain and groundsel. Annual grasses such as barnyard grass, crab grass, wild oats and yellow foxtail. Most perennial species starting freshly from seed. Does not control triazine-resistant biotypes of foxtail, lamb's-quarters, pigweed and groundsel.

Uptake and Translocation:

Absorbed by roots, but little or no foliar absorption. Translocated upwards in xylem, accumulating in apical meristem and leaves with napropamide on new plantings of apples, apricots, cherries, plums, peaches and pears.

Basis of Selectivity:

Some species, such as corn, metabolize simazine. In most crops, selectivity depends on crop-plant roots being deeper than the depth to which simazine leaches.

Application Methods:

Remove any existing weeds from containers before application. Apply once per season, 1 month after planting and before weeds emerge.

Residual Activity:

Persists longer than atrazine. Soil residues may persist for more than 1 season. Do not plant any crop but corn in the treated area for 1 year after a simazine application. If you applied more than 2 kg/ha, do not plant rotational crops the following year. Test soils for excess residues if questions exist.

Unique Characteristics:

Apply only once per season. Needs sufficient moisture to activate. Rotate with non-triazine residual herbicides to avoid resistant weeds. Where rainfall causes erosion, soil containing simazine may wash to lower land and injure existing or subsequent crops.

Manufacturer:

PRINCEP NINE-T:	*Syngenta Crop Protection Canada Inc.*
SIMADEX:	*Aventis CropScience* Canada
SIMAZINE 80W:	*United Agri Products*
SIMAZINE 480:	*United Agri Products*

Chemical Family: s-metolachlor

Trade Name: **DUAL MAGNUM**

Chemical Family: **Acetanilide**

Rates of Application:

s-metolachlor (915 g/L)	0.14–1.6 kg/ha
Dual II Magnum	1.25–1.75 L/ha

Remarks:

Use on second year or older white spruce, Norway spruce, black spruce, white pine, Jack pine and red pine transplant or seedling stock. Also for use on poplar stoolbeds.

May be applied as a preemergent or early postemergent application to weeds before they pass the 2-leaf stage. For poplar stoolbeds, apply to dormant and flushing stool beds.

Apply to soil prior to bud break. *Do not apply DUAL MAGNUM within 4 weeks after bud burst or until the needles have hardened.*

Sensitive Weeds:

Annual broadleaf weeds and grasses such as American nightshade, Eastern black nightshade, smooth crab grass, hairy crab grass, barnyard grass, redroot pigweed (suppression only), fall panicum, green foxtail, yellow foxtail, giant foxtail, old witchgrass, yellow nut sedge.

Uptake and Translocation:

Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broad leaf weeds through roots and shoots.

Basis of Selectivity:

Metabolized by tolerant species.

Application Methods:

Early preplant, preplant incorporated and preemergence. Early postemergence on corn (spike to 2-leaf stage of corn). Set incorporation equipment to work the soil 10 cm deep with a disc operating at 6–10 km/hr or a vibrating shank cultivator at 10–13 km/hr; one incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application.

Residual Activity:

Activity will normally be maintained for 10–14 weeks.

Unique Characteristics:

The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Winter cereals may be planted 4–5 months after metolachlor application. Many tank mix combinations are registered on various crops. Do not use on muck soils or coarse-textured soils low in organic matter.

Manufacturer: Syngenta Crop Protection Canada Inc.

Common Name: trifluralin

Trade Name: **BONANZA, RIVAL, TREFLAN**

Chemical Family: **Dinitroaniline**

Rates of Application

trifluralin	0.6–1.15 kg/ha
BONANZA 400EC (400 g/L)	1.5–2.75 L/ha
RIVAL (60 DF)	1.0–1.9 g/ha
TREFLAN (480 g/L)	1.1–2.1 kg/ha

Remarks:

Use with field-grown nursery stock, perennials (except *Ajuga*, *Vinca* and *Pachysandra*) and established shelter belts.

Sensitive Weeds:

Effective on most annual grasses. Provides good control of pigweed and lamb's-quarters, including the triazine-tolerant biotypes of these weeds.

Uptake And Translocation:

No significant trifluralin absorption or translocation in crops. Controls susceptible weeds as they germinate. Does not control established weeds.

Basis of Selectivity:

Physiological growth processes associated with seed germination.

Application Methods:

Preplant incorporated. Apply in 100–300 L water/ha. Use a lower rate of the chemical on sandy soils and a greater rate for loam to clay soils. Do not use on highly organic soils (muck, peat or black sands above 15% organic matter). Incorporate twice in cross directions using a tandem disc (7–10 km/hr) or tine cultivator

(10– 13 km/hr) set 8–10 cm deep. Incorporate immediately after application if possible. However, you may delay up to 24 hours as per label directions. Incorporate again any time before planting. Activated upon incorporation — irrigation is not required.

Residual Activity:

Recommended application rates provide season-long weed control. Does not injure succeeding crops under normal conditions. Fall-seeded grain crops will grow in soil treated with trifluralin the preceding spring.

Unique Characteristics:

Strongly absorbed to soil particles and shows negligible leaching. Organic matter and clay content influence the application rate. Does not control ragweed, annual nightshades or mustards. Lady's thumb may escape.

Manufacturer:

BONANZA:	*United Agri Products*
RIVAL:	*Aventis CropScience Canada Inc.*
TREFLAN:	*Dow AgroSciences Canada*

Postemergence Treatments

Postemergence treatments are applied after crops and weeds emerge.

- Selective chemicals kill weeds with little damage to desirable plants.
- Many postemergent treatments are non-selective and can damage desirable plants if used carelessly.
- The types of weeds controlled depend on weed susceptibility and crop tolerance to the chemical. You must apply treatments at the correct stage of crop development. Since weed susceptibility is greatest when most weeds are young, early treatments need less herbicide and cause less crop damage.
- Some herbicides may be applied postemergence to the crop but as preemergence treatments to the weeds. For example, you may cultivate a crop and then apply herbicide to weed-free soil to control subsequent germinating weeds.

Common Name: fluazifop-p-butyl

Trade Name: **VENTURE L**

Chemical Family: **Aryloxyphenoxypropionate**

Rates of Application:

fluazifop-p-butyl	0.075–0.25 kg/ha
VENTURE L (125 g/L)	0.6–2.00 L/ha

Remarks:

Use for field and container application. Good on non-grassy ornamental plants, shrubs, trees, non-bearing forest and ornamental nursery field stock and container grown nursery stock. Over the top application can injure some blue junipers (e.g., *Juniperus horizontalis* Bar Harbour, Blue Acres and Blue Rug).

Cultivars differ in sensitivity to VENTURE L. For example, *J. horizontalis* Blue Acres is sensitive while *J. horizontalis* Plumosa Compacta is tolerant. Consult the label for tolerant species. *Test samples of each cultivar not specifically listed on the label before using this product.*

Sensitive Weeds:

Annual grass species, volunteer corn, wheat, barley and quack grass.

Uptake and Translocation:

Absorbed primarily by leaves. Translocated to roots and rhizomes.

Basis of Selectivity:

Metabolism by tolerant species.

Application Methods:

Postemergence. Use a directed application in sensitive species to avoid contacting leaves and green tissue. Use higher application rates for quack grass. Apply to actively growing grasses when annual grasses are in the 2–5 leaf stage and quack grass is in the 3–5 leaf stage.

Residual Activity:

None.

Unique Characteristics:

Preplant tillage to break up rhizomes improves quack grass control. Do not cultivate for 5 days after application. Except as noted on the label, apply broadleaf herbicides separately and at least 3 days after using this product. Product loses some effectiveness when used on stressed plants (e.g., lack of moisture, excessive humidity, low temperature, very low relative humidity). Weeds may regrow by tillering if you apply product to stressed plants. A new flush of weeds may emerge after the first flush is controlled.

Manufacturer: Syngenta Crop Protection Canada Inc.

Common Name: glyphosate

Trade Name: **CLEAR-IT 1, CLEAR-IT 2, CLEAR-IT 3, EXPEDITE GRASS & WEED KILLER, ROUNDUP**

Chemical Family: **Amino acid**

Rates of Application:

Emerged annual weeds:	
glyphosate	0.8–1.25 kg/ha
ROUNDUP (365 g/L)	2.25–3.5 L/ha
Emerged perennial weeds:	
glyphosate	1.7–4.3 kg/has
ROUNDUP (365 g/L)	4.75–12 L/ha
Quack grass & other perennial grasses:	
glyphosate	0.9–2.5 kg/ha
ROUNDUP (365 g/L)	2.5–7 L/ha
Perennial weeds (Canada thistle, milkweed, bindweed, dogbane, sow thistle):	
glyphosate	2.5–4.3 kg/ha
ROUNDUP (365 g/L)	7–12 L/ha

Remarks:

Apply to actively growing weeds. Spray must not contact leaves or green bark of trees or shrubs.

Crop and/or Non-Crop Registrations:

EXPEDITE GRASS & WEED KILLER, ROUNDUP: mowing and directed application in woody nursery stock.

Sensitive Weeds:

Annual grasses, perennial weeds (e.g., quack grass, Canada thistle, sow thistle, field bindweed, milkweed, cat tails, nut sedge, poison ivy), brush (e.g., birch, alder, poplar, raspberry, willow and maple).

Uptake and Translocation:

Absorbed through foliage and translocated throughout the plant.

Basis of Selectivity:

Non-selective for agricultural crops. Conifers are tolerant at some stages for unknown reasons.

Application Methods:

Use postemergence for perennial weed control. Apply at the bud-bloom growth stage to most perennial weeds. Apply to Canada thistle and sow thistle when at least in early flower bud. Apply to milkweed at flower bud. Apply to bindweed at full flower. Treat quack grass in spring or fall while actively growing with at least 3–4 new leaves on each emerged shoot.

Remove crop refuse in the fall, but do not till before application. Fall or spring tillage before spring application may reduce weed control. Wait at least 3–5 days after application before working the area. For maximum quack grass control, till before quack grass turns completely brown.

Glyphosate can be applied with boom equipment, knapsack sprayers and high volume spray equipment for agricultural and non-crop uses. Use backpack mist blowers *only* for silvicultural site preparation and roadside brush control. Use aerial applications *only* for silvicultural site preparation and conifer release.

You may apply glyphosate with selective equipment to non-crop areas, tree plantings, grapes and orchards. (See *Wiper Applicators for Selective Weed Control* on page 101.) Regardless of application method, do not allow herbicide to contact green foliage or green bark of crop or other desirable plants. Remove all suckers from the trunks of desirable trees before spraying.

Residual Activity:

None — crops can be planted or seeded directly into treated areas following application. Use other herbicides to control weeds emerging after the application.

Unique Characteristics:

Rainfall within 6 hours after application or heavy frost may reduce control.

Manufacturer:

CLEAR-IT 1, 2, 3:	*Monsanto Canada Inc.*
EXPEDITE GRASS & WEED KILLER:	*Monsanto Canada Inc.*
ROUNDUP:	*Monsanto Canada Inc.*

Common Name: paraquat

Trade Name: GRAMOXONE

Chemical Family: Bipyridylium

Rates of Application:

paraquat	0.55–1.1 kg/ha
GRAMOXONE (200 g/L)	2.75–5.5 L/ha

Remarks:

Use for emerged annual weeds and to suppress top growth in perennial weeds.

Crop and/or Non-Crop Registrations:

- stale seedbed technique
- inter-row directed chemical weeding for established nursery crops
- chemical mowing weed control in non-crop land

Sensitive Weeds:

Non-selective action affects all green plants.

Uptake and Translocation:

Absorbed by foliage and green bark. Little or no translocation.

Basis of Selectivity:

All green plant tissue is sensitive. Less effective on plants with a very waxy cuticle and linear leaf shape (e.g. nut sedge). Safe on mature (non green) bark of woody plants.

Application Methods:

Postemergence. Apply when weeds are under 15 cm high. Use as a chemical mower — apply several times a year to actively growing vegetation. Aim spray to avoid leaves and green bark of nursery plants. For spot treatment, use 25 mL in 4 L of water. Only controls emerged weeds. Suppresses perennial weeds. Broadcast if no danger to leaves or bark of desirable plants. Best results when applied on a dull or cloudy day or in the evening.

Residual Activity:

Essentially no residual soil activity. Persists in organic material (e.g., mulches, turf thatch) — do not reseed such areas for 5 days. Perennial weeds may need multiple applications per season.

Unique Characteristics:

Inactivated by adsorption to soil particles. Not available to homeowners. For a domestic registration, see paraquat/diquat.

Manufacturer: Syngenta Crop Protection Canada Inc.

Herbicides Registered in Ontario

The following pages contain charts listing information about all herbicides registered in Ontario for use on ornamental nursery stock.

A successful weed control program combines both cultural and chemical control.

Table 5–3 lists significant label restrictions of commonly used herbicides. Whenever using a pesticide, review the manufacturer's instructions

TABLE 5–3. Herbicide Label and Plant Restrictions

Herbicide	Label and Plant Restrictions
Preemergent	
CHLORO IPC, chlorpropham	Ornamental nursery stock
BONANZA 400, RIVAL, TREFLAN, trifluralin	Ornamental nursery stock *except* ajuga, myrtle and pachysandra
Postemergent	
GRAMOXONE, paraquat	Ornamental nursery stock; avoid contact with foliage
ROUND-UP, gylphosate	Ornamental nursery stock; avoid contact with foliage

TABLE 5–4. Herbicides Registered for use on Woody Plants

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Venture L**	**Kerb**	**Ronstar**	**Simazine, Princep**
Abies balsamea	balsam fir	Not				F		F
Abies sp.	fir	Not			TFC	F		
Acer sp.	maple	T[1]F		TFC	TFC			
Acer circinatum	vine maple						C[2]	
Ajuga sp.	bugleweed	Not						
Betula pendula 'Gracilis'	cutleaf weeping birch	T[1]F						
Buxus sp.	boxwood	T[1]F		TFC	TFC			F
Calluna sp.	heather	T[1]F			TFC			
Caragana sp.	peashrub	T[1]F			TFC			F
Carpinus sp.	blue beech				TFC			
Chaenomeles sp.	flowering quince				TFC			
Chamaecyparis sp.	false cypress							F
Cornus sp.	dogwood				TFCD		C[2]	F
Cotinus coggygria	smoke bush				TFC			
Cotoneaster sp.	cotoneaster				TFC			F
Crataegus sp.	hawthorn			TFC				
Deutzia sp.	deutzia							
Erica sp.	heath	T[1]F						
Euonymus sp.	euonymus sp.	T[1]F		TFC	TFC			
Euonymus fortunei 'Emerald & Gold'	emerald & gold euonymus						C[2]	
Forsythia sp.	forsythia	T[1]F			TFC			
Fraxinus americana	white ash							F
Fraxinus sp.	ash	T[1]F			TFC			
Gleditsia sp.	honeylocust			TF	TFC			
Gleditsia triacanthos	honeylocust				T			
Hedera sp.	English ivy			C	TFC			
Hibiscus sp.	rose of Sharon			TF				
Hydrangea sp.	hydrangea				TFC			
Hypericum sp.	hypericum			TF				
Ilex sp.	holly	T[1]F		TFC	TFC*			F
Juglans nigra	black walnut							F
Juglans sp.	walnut							
Juniperus chinensis Pfitzeriana	pfitzer juniper	T[1]FC[1,2]			TFCD	F		
Juniperus sabina	sabina juniper	T[1]FC[1,2]				F		
Juniperus scopulorum	rocky mountain juniper	T[1]				F		
Juniperus sp.	juniper	T[1]F		TFC	TFC*	F	C[2]	FC
Juniperus virginiana	eastern red cedar	T[1]F				F		
Laburnum sp.	golden chain tree			TF				
Ligustrum sp.	privet			TFC	TFC			

* Directed spray from bud break to initial growth hardening

[1] Apply 4 wks after transplanting

[2] Apply 30 days before covering polyhouses; no later than Sept. 30

C Container

D Directed spray only

F Field

Not Labeled restriction

S Seedbed

T Transplant

TABLE 5–4. Herbicides Registered for use on Woody Plants (Continued)

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Venture L**	**Kerb**	**Ronstar**	**Simazine, Princep**
Liriodendron sp.	tulip tree							
Lonicera sp.	honeysuckle	T[1]F			TFC			
Malus sp.	flowering crabapple	T[1]F		TF	TFC			F
Malus sylvestris (*non producteur*)	apple (non-fruiting)			TFC			F	
Parthenocissus quinquefolia	Virginia creeper				TFC			
Philadelphus sp.	mockorange	T[1]F			TFCD			
Picea abies	Norway spruce	Not				F		F
Picea abies Nidiformis	nest spruce	Not				F		
Picea glauca	white spruce	Not				F		F
Picea glauca Conica	dwarf Alberta spruce	Not				F		
Picea marina	black spruce		TF					
Picea omorika	Serbian spruce	Not					C[2]	
Picea pungens	Colorado spruce	Not					C[2]	
Picea pungens Glauca	blue Colorado spruce	Not				F		F
Picea pungens Glauca Globosa	globe blue spruce	Not				F		F
Picea rubens	red spruce	Not				F		F
Picea sp.	spruce	Not		TF	TFC*	F		
Pieris sp.	Japanese pieris				TFC			
Pinus banksiana	jackpine		TF					
Pinus mugo	mugo pine	Not				F	C[2]	F
Pinus nigra	Austrian pine					F		
Pinus resinosa	red pine		TF					
Pinus sp.	pine			TFC	TFC	F		
Pinus strobus	white pine 2 year		TF		F		F	
Pinus sylvestris	scotch pine						C[2]	
Pittosporum sp.	pittosporum			TF				
Platanus sp.	planetree				TFC			
Podocarpus sp.	podocarpus			TFC				
Populus sp.	poplar		stoolbed	TF				
Potentilla sp.	cinquefoil				TFC		C[2]	
Prunus sp.	cherry (non producing)			TF				
Prunus tomentosa	nanking cherry						C[2]	
Pseudotsuga menzeisii	douglas fir				TFC*	F		
Pyracantha sp.	firethorn			TFC	TFC			
Pyrus sp.	pear (non producing)							

*	Directed spray from bud break to initial growth hardening	D	Directed spray only
[1]	Apply 4 wks after transplanting	F	Field
[2]	Apply 30 days before covering polyhouses; no later than Sept. 30	Not	Labeled restriction
C	Container	S	Seedbed
		T	Transplant

TABLE 5–4. Herbicides Registered for use on Woody Plants (Continued)

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Venture L**	**Kerb**	**Ronstar**	**Simazine, Princep**
Quercus sp.	oak							
Rhododendron sp.	rhododendron, azalea	T[1]F		TFC	TFC			
Ribes sp.	currant (non producing)				TFC			
Ribes alpinum	alpine currant						C[2]	
Robinia pseudoacacia	black locust							
Robinia sp.	locust	T[1]F						
Rosa multiflora	multiflora rose							F
Rosa sp.	rose	T[1]F		TFC	TFC			F
Salix sp.	willow	T[1]F			TFC			
Sambucus sp.	elderberry				TFC			
Sambucus canadensis Aurea	golden elderberry						C[2]	
Spiraea sp.	spirea	T[1]F			TFC			
Symphoricarpos rivularis	snowberry				TFC			
Syringa sp.	lilac	Not			TFC		C[2]	
Taxus cuspidata	Japanese yew					F		
Taxus sp.	yew	T[1]FC[1,2]		TF	TFC[*]	F		FC
Thuja occidentalis	white cedar	T[1]FC[1,2]				F		
Thuja sp.	cedar	T[1]F		C	TFC	F		FC
Tilia sp.	linden, basswood	T[1]F			TFC			
Tsuga sp.	hemlock	Not			TFC[*]			F
Ulmus sp.	elm	T[1]F			TFC			
Viburnum sp.	viburnum				TFC			
Weigela sp.	weigela				TFC			

[*] Directed spray from bud break to initial growth hardening

[1] Apply 4 wks after transplanting

[2] Apply 30 days before covering polyhouses; no later than Sept. 30

C Container

D Directed spray only

F Field

Not Labeled restriction

S Seedbed

T Transplant

TABLE 5–5. Weed Susceptibility and Herbicides — Broadleaf Annuals

Broadleaf Annuals	Casoron	Cipc	Dual Magnum	Devrinol	Kerb	Ronstar	Simazine Princep	Trefelan, Rival, Trifluralin
bittercress	S					S		
buckwheat, wild	S						S	MS
carpetweed		S		S				S
chickweed, common	S	S		S	S			S
clover, volunteer							S	
cocklebur								
false flax		S						
galinsoga								
groundsel, common	S			S		S		
ground cherry								
jimsonweed								
knotweed	S							
knotweed, prostrate				S				S
kochia								
lady's thumb							S	
lamb's quarters	S			S		S	S	S
mustards	S							
nightshade, black			MS			S		
pigweed	S			S		S		S
pigweed, redroot				S			S	
pineappleweed				S				
plantain	S							
prickly lettuce				S				
purslane	S	S		S		S	S	S
ragweed, common				MS			S	
russian thistle								S
shepherd's-purse	S					S		
smartweed	S	S					S	S
smartweed, green							S	
sow-thistle, annual	S			S				
spurge	S							
stinkweed						S		
velvetleaf								

S = Susceptible; MS = Moderately Susceptible; T = Tolerant

TABLE 5–6. Weed Susceptibility and Herbicides — Broadleaf Perennials

Broadleaf Perennials	Casoron	Cipc	Dual Magnum	Devrinol	Venture L	Kerb	Ronstar	Simazine	Trifluralin	Roundup
bindweed	T								T	S
chickweed mouse eared	MS								MS	S
dandelion	MS			T						MS
grape, wild	T									MS
ground ivy (creeping Charlie)	MS									MS
horsetail	MS	T						T	T	MS
mallow										MS
milkweed									T	S
nut sedge	MS		S	MS	T			T	T	MS
plantains	MS									S
poison ivy					S					
quack grass	MS	T		T	MS	MS		T	T	
sow thistle	MS	T				S		T	T	
stinging nettle					S					
thistle, canada	MS	T						T	T	
toadflax, yellow					S	S				S
vetches	MS			T				T	T	
viriginia creeper										

S = Susceptible; MS =Moderately Susceptible; T =Tolerant

TABLE 5–7. Weed Susceptibility and Herbicides — Annual Grasses

Annual Grasses	**Casoron**	**Cipc**	**Dual Magnum**	**Devrinol**	**Venture L**	**Garden Weed Preventer**	**Kerb**	**Ronstar**	**Simazine**	**Trifluralin**	**Roundup**
barnyard grass			S	S	S	S		S	S	S	
bluegrass, annual	S	S		S				S		S	S
brome grass										S	S
cheat grass										S	
crab grass	S	S		S	S	S		S	S	S	
crab grass, large				S							S
crab grass, smooth			S								
darnel, persian					S					S	
foxtail, giant			S		S	S					
foxtail, green	S		S	S	S	S		S		S	S
foxtail, yellow	S		S	S	S	S		S	S	S	
goosegrass				S						S	
grasses, annual							S				
johnson grasss					S						
love (stink) grass		S								S	
oats, wild				S	S		S		S	S	S
panicum											
panicum, fall			S	S		S				S	
proso millet					S						
ryegrass		S		S							
witch grass			S								

S = Susceptible; MS =Moderately Susceptible; T =Tolerant

6. Appendices

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APPENDIX A. Ontario Ministry of Agriculture and Food Advisory Staff List

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Manager, Greenhouse, Agroforestry and Specialty Crops	Annette Anderson	(519) 826-3286 Fax (519) 826-3567	annette.anderson@omaf.gov.on.ca
Manager, Horticulture Technology	Hugh Berges	(519) 826-3288 Fax (519) 826-3567	hugh.berges@omaf.gov.on.ca
Manager, Horticulture Crops	John Finlay	(519) 826-6941 Fax (519) 826-3567	john.finlay@omaf.gov.on.ca
Manager, Field Crops	Brent Kennedy	(519) 826-3257 Fax (519) 826-3567	brent.kennedy@omaf.gov.on.ca
Apiary Specialist	Doug McRory	(519) 826-3595 Fax (519) 826-3567	doug.mcrory@omaf.gov.on.ca
Applied Research Coordinator – Horticulture	Vacant		
Crop Protection Program Lead	Craig Hunter (currently on assignment)	(519) 826-4189 Fax (519) 826-3259	craig.hunter@omaf.gov.on.ca
Marketing and Communications Officer	Cathy Wilson Pinkney	(519) 826-3150 Fax (519) 826-3259	cathy.wilsonpinkney@omaf.gov.on.ca
Minor Use Coordinator	Jim Chaput	(519) 826-3539 Fax (519) 826-4964	jim.chaput@omaf.gov.on.ca
On-Farm Food Safety Program Lead	Sandra Jones	(519)826-3289 Fax (519)826-4964	sandra.jones@omaf.gov.on.ca
Organic Crop Production Program Lead	Hugh Martin	(519) 826-4587 Fax: (519) 826-4964	hugh.martin@omaf.gov.on.ca
Potato Specialist	Dr. Eugenia Banks	(519) 826-3678 Fax (519) 826-4964	eugenia.banks@omaf.gov.on.ca
Product Development Specialist	Kelly Ward	(519) 826-4094 Fax (519) 826-4964	kelly.ward@omaf.gov.on.ca
Vegetable Crops Specialist	Kristen Callow	(519) 826-4963 Fax (519) 826-4964	kristen.callow@omaf.gov.on.ca

University of Guelph
General Phone (519) 824-4120
50 Stone Road East Guelph, ON N1G 2W1

Applied Research Coordinator – Field Crops, Crop Science Building	Ian McDonald	(519) 824-4120 Ext. 6707 Fax (519) 763-8933	ian.mcdonald@omaf.gov.on.ca
Corn Industry Program Lead Crop Science Building	Greg Stewart	(519) 824-4120 Ext. 4865 Fax (519) 763-8933	greg.stewart@omaf.gov.on.ca
Nursery Crops Specialist Edmund Bovey Building	Jennifer Llewellyn	(519) 824-4120 Ext. 2671 Fax (519) 767-0755	jennifer.llewellyn@omaf.gov.on.ca
Nutrition – Horticulture Program Lead Land Resource Science Richards Building	Christoph Kessel	(519) 824-4120 Ext. 2480 Fax (519) 824-5730	christoph.kessel@omaf.gov.on.ca
Pathologist – Horticulture Crops Program Lead, Edmund Bovey Building	Michael Celetti	(519) 824-4120 Ext. 8910 Fax (519) 767-0755	michael.celetti@omaf.gov.on.ca
Turfgrass Specialist Guelph Turfgrass Institute 328 Victoria Rd S R. R. # 2 Guelph, ON N1H 6H8	Pam Charbonneau	(519) 824-4120 Ext. 2597 Fax (519) 766-1704	pamela.charbonneau@omaf.gov.on.ca
Weed Management Field Crops Program Lead, Crop Science Building	Mike Cowbrough	(519) 824-4120 Ext. 2580 Fax (519) 763-8933	mike.cowbrough@omaf.gov.on.ca

Agricultural Information Contact Centre
General Phone 1-877-424-1300 or (519) 826-4047 Fax (519) 826-7610

Provides province-wide, toll-free technical and business information to commercial farms, agri-businesses and rural businesses.

1 Stone Road, West Guelph ON N1G 4Y2 e-mail ag.info@omaf.gov.on.ca

Guelph — Government Information Centre
Staff Directories — Phone 1-888-466-2372 or (519) 826-3100
1 Stone Road West Guelph ON N1G 4Y2

APPENDIX B. Tissue Testing and Accredited Soil Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

Company	Address		Contact
A & L Canada Laboratories East, Inc. 2136 Jetstream Road London, Ontario N5V 3P5	Tel (519)457-2575 Fax (519) 457-2664	Web www.al-labs-can.com email aginfo@al-labs-can.com	Greg Patterson Ian McLachlin
Accutest Laboratories 146 Colonnade Road, Unit #8 Nepean, Ontario K2E 7Y1	Tel (613) 727-5692 Fax (613) 727-5222	Web www.accutestlabs.com email phaulena@accutestlabs.com	Lorna Wilson Peter Haulena
Agri-Food Laboratories 503 Imperial Road, Unit #1 Guelph, Ontario N1H 6T9	Tel (519) 837-1600 1-800-265-7175 Fax (519) 837-1242	Web www.agtest.com email lab@agtest.com	Dale Cowan Nora Wilson
Brookside Laboratories Inc. 301 South Main Street New Knoxville, Ohio 45871	Tel (419) 753-2448 Fax (419) 753-2949	email nfisher@blinc.com	
Soil and Nutrient Laboratory University of Guelph P.O. Box 3650, 95 Stone Road West Guelph, Ontario N1H 2W1	Tel (519) 767-6226 Fax (519) 767-6240	email vkerslak@lsd.uoguelph.ca	Virginia Kerslake
Stratford Agri Analysis Inc. (A Daco Laboratories Ltd. Company) 1131 Erie Street, Box 760 Stratford, Ontario N5A 6W1	Tel (519) 273-4411 1-800-323-9089 Fax (519) 273-4411	email saa@dacolabs.com	Dale Peters Keith Lemp

There is no official accreditation in Ontario for tissue analysis, but all of the accredited soil testing labs are monitored for proficiency on tissue analyses.

APPENDIX C. Ontario Ministry of the Environment Pesticides Control Offices

Region/County	Pesticides Officer Address	Telephone/Fax
Central Region Toronto, Halton, Peel, York, Durham	**Charles Zubovits** **Cathy Wright** 5775 Yonge Street, 8th Floor Toronto, Ontario M2M 4J1	Tel (416) 326-6700 Toll free 1-800-810-8048 Fax (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	**Charlie Roland** Ontario Government Building 119 King Street West, 12th Floor Hamilton, Ontario L8P 4Y7	Tel (905) 521-7640 Toll free 1-800-668-4557 Fax (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Townships of Airy, Murchison, Dickens, Lyell and Sabine)	**Roberto Sacilotto** 133 Dalton Avenue Kingston, Ontario K7L 4X6	Tel (613) 549-4000 Toll free 1-800-267-0974 (in Eastern region only) Fax (613) 548-6908
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth,Simcoe	**Gary Roberts** 659 Exeter Road, 2nd Floor London, Ontario N6E 1L3	Tel (519) 873-5000 Toll free 1-800-265-7672 Fax (519) 873-5020
Northern Region East Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Haliburton, Muskoka	**John Negusanti** 199 Larch Street, Suite 1101 Sudbury, Ontario P3E 5P9	Tel (705) 564-3249 Fax (705) 564-4180
Northern Region West Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West	**Don Mitchell** 435 James St. S., Suite 331 Thunder Bay, Ontario P7E 6S7	Tel (807) 475-1712 Toll free 1-800-875-7772 Fax (807) 475-1754
Standards Development Branch	Pesticides Section 40 St. Clair Avenue West, 7th Floor Toronto, Ontario M4V 1M2	Tel (416) 327-5519 Fax (416) 327-2936
Approvals Branch	Pesticides Licensing 2 St. Clair Avenue West, 12A Floor Toronto, Ontario M4V 1L5	Tel (416) 314-8001 Toll Free 1-800-461-6290 Fax (416) 314-8452

APPENDIX D. Other Contacts

AGRICULTURE & AGRI-FOOD CANADA

Research Centres
Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue
Ottawa, K1A 0C6
Tel (613) 759-1952
Web site http://res2.agr.ca/ecorc/index_e.htm

Greenhouse and Processing Crops Research Centre
Harrow N0R 1G0
Tel (519) 738-2251
Web site http://res2.agr.ca/harrow/

Southern Crop Protection and Food Research Centre
Web site http://res2.agr.ca/london/pmrc
1391 Sandford Street
London N5V 4T3
Tel (519) 457-1470

Vineland Research Farm
4902 Victoria Avenue North
Vineland L0R 2E0
Tel (905) 562-4113

Delhi Research Farm
Box 186 Schafer Road
Delhi N4B 2W9
Tel (519) 582-1950

CANADIAN FOOD INSPECTION AGENCY
Web site www.cfia-acia.agr.ca

Regional Offices (Plant Protection)
Belleville, 345 College Street East
Belleville, K8N 5S7
Tel (613) 969-3333

Brantford, Federal Building, Dalhousie & Queen St.,
P.O. Box 637
Brantford, N3T 5P9
Tel (519) 751-8157

Hamilton, 709 Main Street West, Suite 101
Hamilton, L8S 1A2
Tel (905) 572-4152

London
1200 Commissioners Road East, Unit 19
London, N5Z 4R3
Tel (519) 691-1300

Niagara Falls
Mailing address: R.R. 1, P.O. Box 7, Niagara Falls, L0S 1J0
Street address: 14154 Niagara River Parkway, Unit 5
Niagara-on-the-Lake
Tel (905) 262-5331

Ottawa District
3 Observatory Crescent
Building #3 Central, Experimental Farm
Ottawa, K1A 0C9
Tel (613) 759-1571

Toronto, 401 Champagne Drive, Unit 1
Downsview, M3J 2C6
Tel (416) 954-1714

Windsor, 441 University Avenue West, Suite 208
Windsor, N9A 5P9
Tel (519) 252-7095

UNIVERSITY OF GUELPH
Main Campus, Guelph, N1G 2W1
Tel (519) 824-4120
Web site www.uoguelph.ca

Alfred College, Alfred, K0B 1A0
Tel (613) 679-2218
Web site www.alfredc.uoguelph.ca

Kemptville College, Kemptville, K0G 1J0
Tel (613) 258-8336
Web site www.kemptvillec.uoguelph.ca

Ridgetown College, Ridgetown, N0P 2C0
Tel (519) 674-1500
Web site www.ridgetownc.on.ca

Department of Plant Agriculture
Web site www.plant.uoguelph.ca

Department of Plant Agriculture, Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
Tel (905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Road
Simcoe, N3Y 4N5
Tel (519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Avenue North
Vineland Station, L0R 2E0
Tel (905) 562-4141

Lab Services Division
Web site www.uoguelph.ca/labserv/

Pesticide and Trace Contaminants
P.O. Box 3650, 95 Stone Road West,
Guelph, N1H 8J7
(519) 767-6200

Pest Diagnostic Clinic
(519) 767-6256

AGRICORP (Crop Insurance)

Customer Action Centre
P.O. Box 3660 Station Central, Guelph, N1H 8M4
Tel 1-888-AGRI-999 (1-888-247-4999)
Web site www.agricorp.com

APPENDIX E. Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematode counts and Verticillium testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Road West
Guelph Ontario, N1H 8J7
Tel: (519) 767-6256
Fax: (519) 767-6240
E-mail pdc@lsd.uoguelph.ca
Web site: www.uoguelph.ca/pdc

Payment must accompany samples at the time of submission. Submission forms are available at the clinic's Web site.

Fee Schedule

Procedures	**Price/ Sample**
Plant Diseases	
Diagnosis not requiring plating	$25.00
Diagnosis requiring plating	$40.00
Turf diagnosis	$50.00
Bacterial identification using Biolog®	$95.00
Detection of virus using Transmission Electron Microscopy	$85.00
Detection of virus using ELISA (turnaround time = 5 working days; bulk rates available)	$60.00
Weed identification	$40.00
Insects	
Basic identification	$25.00
Identification requiring dissection and/or extensive keys	$40.00
Nematode and Verticillium Counts	**Price/ Sample**
Nematodes extracted from soil (Bearman Pan Method)	$25.00
SCN cyst count + egg count	$35.00
Nematodes extracted from roots	$60.00
Verticillium count	$60.00

Turnaround time:
Nematodes extracted from soil = 7 to 8 days
Nematodes extracted from roots = 15 days
Cyst counts = 3 to 4 days

Charges will be applied to each sample submitted.
Payment: Please make cheque payable to the University of Guelph. VISA and Mastercard are accepted. Please do not mail cash.

How to Sample for Nematodes

Soil

When to Sample
Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in Sept. and Oct.

How to Sample Soil
Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of 1/2–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac). Mix subsamples in a clean pail or plastic bag.

Sampling Pattern
If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

Number of Subsamples
Based on the total area sampled:

500 m^2 (5,400 ft^2)	10 subsamples
500 m^2–0.5 ha (5,400 ft^2–1.25 ac)	25 subsamples
0.5 ha–2.5 ha (1.25–6.25 ac)	50 subsamples

Roots

From small plants, sample the entire root system plus adhering soil. For large plants, 10–20 g (1/2–1 oz.) dig fresh weight from the feeder root zone and submit.

Problem Areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take samples from healthy areas in the same field. If possible, take both soil and root samples from problem and healthy areas in the same field.

Sample Handling

Soil Samples
Place in plastic bags as soon as possible after collecting.

Root Samples
Place in plastic bags and cover with moist soil from the sample area.

Storage
Store samples at 5–10°C (40–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). **Only living nematodes can be counted. Accurate counts depend on proper handling of samples.**

Submitting Plant for Disease Diagnosis or Identification

Sample Submission Forms

Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm^2 piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch, and include healthy and unhealthy turf, as well as the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. **Completely dead material is usually inadequate for diagnosis**.

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and contamination of the leaves by soil. Do **NOT** add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting Samples

Place dead, hard-bodied insects and spiders in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

UNIVERSITY of GUELPH LABORATORY SERVICES

95 Stone Road West
Guelph, ON N1H 8J7
Tel: (519) 767-6256
Fax: (519) 767-6240
Web: www.uoguelph.ca/pdc

Pest Diagnostic Clinic

SAMPLE SUBMISSION FORM

LABORATORY USE ONLY: **LS Form: SubP01/04/03**
Rec'd: By:____________ **Date Received:** ____________
Delivered By: ☐ **Mail** ☐ **Courier** ☐ **In-Person**
LS Sample No: ______________ **to** ______________
Payment Rec'd: $__________ **Receipt #:**__________

Submitted By:			Owner (if different from submitter):		
Business Name (if applicable):			Business Name (if applicable):		
Street:			Street:		
City:	Prov:	Postal Code:	City:	Prov:	Postal Code:
Tel: ( ) -	Fax: ( ) -		Tel: ( ) -	Fax: ( ) -	
Email:			Email:		

Unless otherwise indicated, report and invoice will be sent to submitter.

Report to: ☐ Submitter ☐ Owner Required Report Format: ☐ Fax ☐ E-Mail ☐ Mail

Invoice to: ☐ Submitter ☐ Owner Quotation #: _________ Purchase Order / U of G G/L code:____________________

Services Required: ☐ Nematode Count ☐ Nematode Count from Roots ☐ SCN Cyst & Egg Count ☐ Verticillium Count
☐ Plant Disease Diagnosis ☐ Insect Identification ☐ Plant Identification ☐ Triazine Resistance Test

Plant or Host Affected:		Cultivar/Variety:	Grower/Field sample #:
		Location of Plant (i.e. greenhouse, field, orchard, garden, etc.):	
Size of Planting:	% of Plants Affected:	Symptoms First Appeared in Past: ☐ Days ☐ Weeks ☐ Months ☐ Years	Degree of Injury: ☐ Severe ☐ Moderate ☐ Light
Cropping History:		Future Crop:	

Describe the problem in detail (i.e. symptoms, plant parts affected, distribution of symptoms):

Were chemicals applied? Please specify type of product(s) used and date(s) of application:

Additional comments and specific requests:

Additional sheet(s) attached: ☐

APPENDIX F. List of Monitoring Equipment and Biological Agent Suppliers

The following is a partial list of suppliers of IPM monitoring equipment, including weather machines, monitoring equipment, and biological control agents.

Note: Inclusion in this list of companies does not imply any endorsement or recommendation by the Ontario Ministry of Agriculture and Food.

Company	Contact	Products
Cooper Mill Ltd. R.R. # 3 Madoc, Ontario K0K 2K0	Phone: (613) 473-4847 Fax: (613) 473-5080 Email: ipm@coopermill.com Web site: www.coopermill.com	Pheromone lures and traps
Gempler's 100 Countryside Drive, Belleville, Wisconsin 53508	Phone: 1-800-382-8473 Fax: 1-800-551-1128 Web site: www.gemplers.com	Weather monitoring equipment Pheromone lures and traps Apple maggot spheres Tangle trap Magnifiers Tally counters
Great Lakes IPM 10220 Church Road NE Vestaburg, Michigan 48891	Phone: (989) 268-5693 Fax: (989) 268-5311 Email: glipm@nethawk.com Web site: www.greatlakesipm.com	Apple scab monitoring equipment Pheromone lures and traps Apple maggot spheres Tangle trap Magnifiers Tally counters Insect sweep nets Field diagnostic equipment
Natural Insect Control R.R. # 2 Stevensville, Ontario L0S 1S0	Phone: (905) 382-2904 Fax: (905) 382-4418 Email: nic@niagara.com Web site: www.naturalinsectcontrol.com	Beneficial insects, mites and nematodes Pheromone traps and lures Mating disruption devices Bird houses
Phero Tech 7572 Progress Way Delta, B.C. V4G 1E9	Phone: (604) 940-9944 Fax: (604) 940-9433 Email: sales@pherotech.com Web site: www.pherotech.com	Pheromone lures and traps
Plant Products Co. Ltd. 314 Orenda Rd. East Brampton, Ontario L6T 1G1	Phone: 1-800-387-2449 Fax: (905) 793-9157 Email: sales@plantprod.com	Beneficial insects and mites Magnifiers
N.M. Bartlett Inc. 4509 Bartlett Road Beamsville, ON L0R 1B1	Phone: (905) 563-8261 Fax: (905) 563-9544 Web site: www.bartlett.ca	Pheromone lures and traps
Solida Distributions 480 Rang St-Antoine St. Ferred-Les-Neiges, Quebec G0A 3R0	Phone: (418) 826-0900 Fax: (418) 826-0901 Email: solida@clic.net	
Warwick Orchards and Nursery R.R. # 8 Watford, Ontario N0M 2S0	Phone: (519) 849-6730 Fax: (519) 849-6731	Dewit leaf wetness sensors

Metric Units

Linear Measures (length)

10 millimetres (mm) = 1 centimetre (cm)
100 centimetres (cm) = 1 metre (m)
1,000 metres = 1 kilometre (km)

Square Measures (area)

100 m x 100 m = 10,000 m^2 = 1 hectare (ha)
100 ha = 1 square kilometre (km^2)

Cubic Measures (volume)

Dry Measure

1,000 cubic millimetres (mm^3) = 1 cubic centimetre (cm^3)
1,000,000 cm^3 = 1 cubic metre (m^3)

Liquid Measure

1,000 millilitres (mL) = 1 litre (L)
100 L = 1 hectolitre (hL)

Weight-Volume Equivalents (for water)

(1.00 kg) 1,000 grams = 1 litre (1.00 L)
(0.50 kg) 500 g = 500 mL (0.50 L)
(0.10 kg) 100 g = 100 mL (0.10 L)
(0.01 kg) 10 g = 10 mL (0.01 L)
(0.001 kg) 1 g = 1 mL (0.001 L)

Weight Measures

1,000 milligrams (mg) = 1 gram (g)
1,000 g = 1 kilogram (kg)
1,000 kg = 1 tonne (t)
1 mg/kg = 1 part per million (ppm)

Dry–Liquid Equivalents

1 cm^3 = 1 mL
1 m^3 = 1000 L

Metric Conversions

5 mL = 1 tsp
15 mL = 1 tbsp
28.5 mL = 1 fl. oz.

Application Rate Conversations

Metric to Imperial (Approximate)

litres per hectare x 0.09 = gallons per acre
litres per hectare x 0.36 = quarts per acre
litres per hectare x 0.71 = pints per acre
millilitres per hectare x 0.015 = fluid ounces per acre
grams per hectare x 0.015 = ounces per acre
kilograms per hectare x 0.89 = pounds per acre
tonnes per hectare x 0.45 = tons per acre

Imperial to Metric (Approximate)

gallons per acre x 11.23 = litres per hectare (L/ha)
quarts per acre x 2.8 = litres per hectare (L/ha)
pints per acre x 1.4 = litres per hectare (L/ha)
fluid ounces per acre x 70 = millilitres per hectare (mL/ha)
tons per acre x 2.24 = tonnes per hectare (t/ha)
pounds per acre x 1.12 = kilograms per hectare (kg/ha)
ounces per acre x 70 = grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50 L/ha	=	5 gal./acre
100 L/ha	=	10 gal./acre
150 L/ha	=	15 gal./acre
200 L/ha	=	20 gal./acre
250 L/ha	=	25 gal./acre
300 L/ha	=	30 gal./acre

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 g/ha	=	1½ oz./acre
200 g/ha	=	3 oz./acre
300 g/ha	=	4¼ oz./acre
500 g/ha	=	7 oz./acre
700 g/ha	=	10 oz./acre
1.10 kg/ha	=	1 lb./acre
1.50 kg/ha	=	1¼ lb./acre
2.00 kg/ha	=	1¾ lb./acre
2.50 kg/ha	=	2¼ lb./acre
3.25 kg/ha	=	3 lb./acre
4.00 kg/ha	=	3½ lb./acre
5.00 kg/ha	=	4½ lb./acre
6.00 kg/ha	=	5¼ lb./acre
7.50 kg/ha	=	6¾ lb./acre
9.00 kg/ha	=	8 lb./acre
11.00 kg/ha	=	10 lb./acre
13.00 kg/ha	=	11½ lb./acre
15.0 kg/ha	=	13½ lb./acre

Conversion Tables — Metric to Imperial

Length

1 millimetre (mm) = 0.04 inch
1 centimetre (cm) = 0.40 inch
1 metre (m) = 39.40 inches
1 metre (m) = 3.28 feet
1 metre (m) = 1.09 yards
1 kilometre (km) = 0.62 mile

Area

1 square centimetre (cm^2) = 0.16 square inch
1 square metre (m^2) = 10.77 square feet
1 square metre (m^2) = 1.20 square yards
1 square kilometre (km^2) = 0.39 square mile
1 hectare (ha) = 107,636 square feet
1 hectare (ha) = 2.5 acres

Volume (dry)

1 cubic centimetre (cm^3) = 0.061 cubic inch
1 cubic metre (m^3) = 1.31 cubic yards
1 cubic metre (m^3) = 35.31 cubic feet
1,000 cubic metres (m^3) = 0.81 acre-foot
1 hectolitre (hL) = 2.8 bushels

Volume (liquid)

1 millilitre (mL) = 0.035 fluid ounce
1 litre (L) = 1.76 pints
1 litre (L) = 0.88 quart
1 litre (L) = 0.22 gallon (Imp.)
1 litre (L) = 0.26 gallon (U.S.)

Weight

1 gram (g) = 0.035 ounce
1 kilogram (kg) = 2.21 pounds
1 tonne (t) = 1.10 short tons
1 tonne (t) = 2,205 pounds

Pressure

1 kilopascal (kPa) = 0.15 pounds/in.^{2}

Speed

1 metre per second = 3.28 feet per second
1 metre per second = 2.24 miles per hour
1 kilometre per hour = 0.62 mile per hour

Temperature

°F = (°C X 9/5) + 32

Conversion Tables — Imperial to Metric

Length

1 inch = 2.54 cm
1 foot = 0.30 m
1 yard = 0.91 m
1 mile = 1.61 km

Area

1 square foot = 0.09 m^2
1 square yard = 0.84 m^2
1 acre = 0.40 ha

Volume (dry)

1 cubic yard = 0.76 m^3
1 bushel = 36.37 L

Volume (liquid)

1 fluid ounce (Imp.) = 28.41 mL
1 pint (Imp.) = 0.57 L
1 gallon (Imp.) = 4.55 L
1 gallon (U.S.) = 3.79 L

Weight

1 ounce = 28.35 g
1 pound = 453.6 g
1 ton = 0.91 tonne

Pressure

1 pound per square inch = 6.90 kPa

Temperature

°C = (°F – 32) x 5/9

Handy Metric Conversion Factor
Litres per hectare x 0.4 = litres per acre
Kilograms per hectare x 0.4 = kilograms per acre

Abbreviations

% = per cent (by weight)
ai = active ingredient
AP = agricultural powder
cm = centimetre
cm^2 = square centimetre
DG = dispersible granular
DP = dispersible powder
E = emulsifiable
e.g. = for example
EC = emulsifiable concentrate
F = flowable
g = gram
Gr = granules, granular
ha = hectare
kg = kilogram
km/h = kilometres per hour
kPa = kilopascal
L = litre
m = metre
m^2 = square metre
mL = millilitre
mm = millimetre
m/s = metres per second
SC = sprayable concentrate
SP = soluble powder
t = tonne
W = wettable (powder)
WDG = water dispersible granular
WP = wettable powder

APPENDIX H. Pest Monitoring Record Sheet

Date (MM/DD/YR)	**Location** (Farm, Block, Landmarks)	**Host** (Include Variety/Cultivar, Development Stage)	**Pest and/or Symptoms** (Development Stage, Population, % plant with symptom)	**GDD, Plant Phenology Indicator**	**Action Taken** (Pesticides, Cultural Measures etc.)

Pest Monitoring Record Sheet

Date (MM/DD/YR)	**Location** (Farm, Block, Landmarks)	**Host** (Include Variety/Cultivar, Development Stage)	**Pest and/or Symptoms** (Development Stage, Population, % plant with symptom)	**GDD, Plant Phenology Indicator**	**Action Taken** (Pesticides, Cultural Measures etc.)

Colour Plates

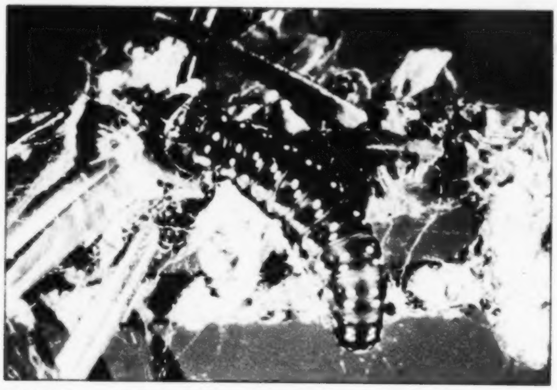

PLATE 1. Late instar spruce budworm (*Choristoneura fumiferana*) larva.

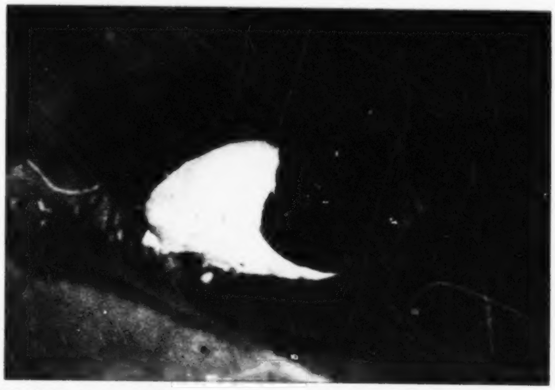

PLATE 2. Adult female cottony maple scale (*Pulvinaria innumerabilis*) with cottony mass of eggs.

PLATE 3. Late instar larvae of the forest tent caterpillar (*Malacosoma disstria*).

PLATE 4. Adult female European fruit lecanium scale (*Lecanium corni*).

PLATE 5. Leaf webbing and feeding damage caused by the maple trumpet skeletonizer (*Epinotia aceriella*).

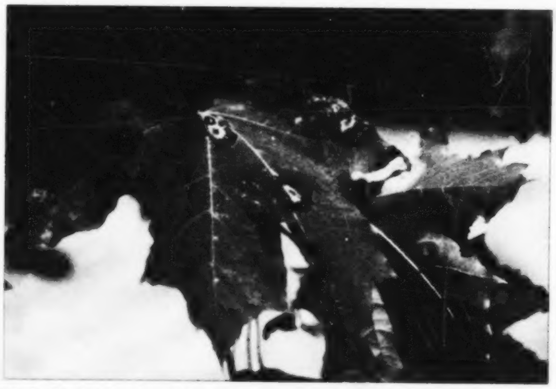

PLATE 6. Tar spot (*Rhytisma acerinum, R. punctatum*) lesions on *Acer platanoides*, early August.

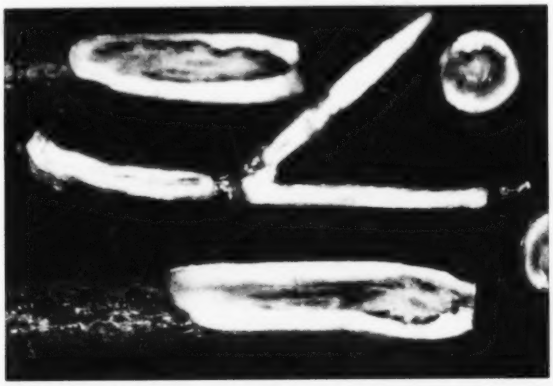

PLATE 7. *Verticillium* (*V. dahliae, V. albo-atrum*) wilt staining on heartwood (xylem) of *Acer* sp.

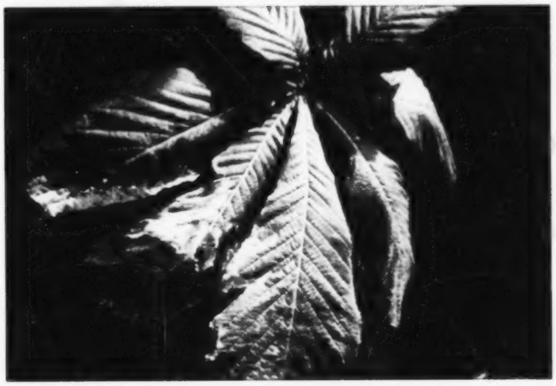

PLATE 8. Leaf blotch (*Guignardia aesculi*) on *Aesculus* sp., July.

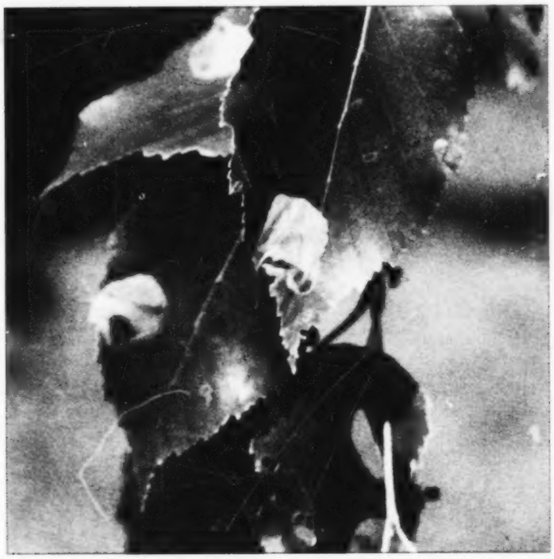

PLATE 9. Mines on leaves caused by the birch leaf miner (*Fenusa pusilla* and other spp.), late May.

PLATE 10. Larval tunnels of bronze birch borer (*Agrilus anxius*). The tunnels circle the trunk, causing raised vericose vein-like swellings in bark.

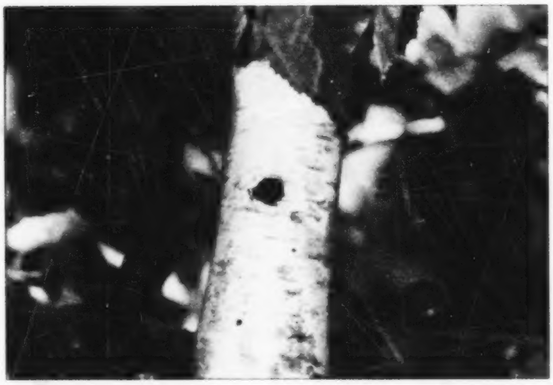

PLATE 11. "D"-shaped exit hole in bark caused by bronze birch borer (*Agrilus anxius*).

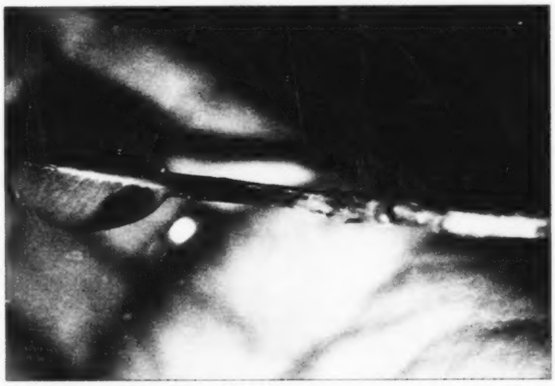

PLATE 12. Distinctive purplish-black lesions of *Volutella canker (Volutella buxi)* on *Buxus* sp.

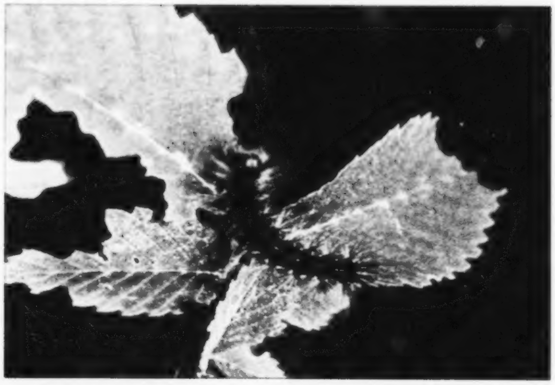

PLATE 13. Late instar larva of Gypsy moth (*Lymantria dispar*), late May. Note 5 pairs of blue dots followed by 6 pairs of red dots along back.

PLATE 14. Adult female Gypsy moth (*Lymantria dispar*) depositing brown, fuzzy egg mass on tree trunk, early August.

PLATE 15. Hawthorn rust (*Gymnosporangium globosum*) on *Crataegus* sp., August. Aecia on leaf undersides release aeciospores that infect *Juniperus.*

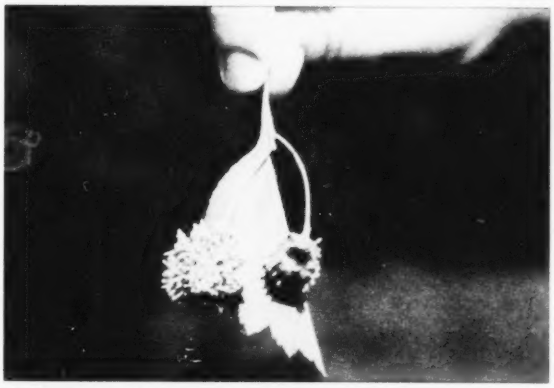

PLATE 16. Quince rust (*Gymnosporangium claviceps*) on *Crataegus* sp., August. Aecia releasing aeciospores that can infect *Juniperus.*

PLATE 17. Representative damage by white grubs (*Rhizotrogus majalis* and *Phyllophaga* sp.) on *Cornus*, September.

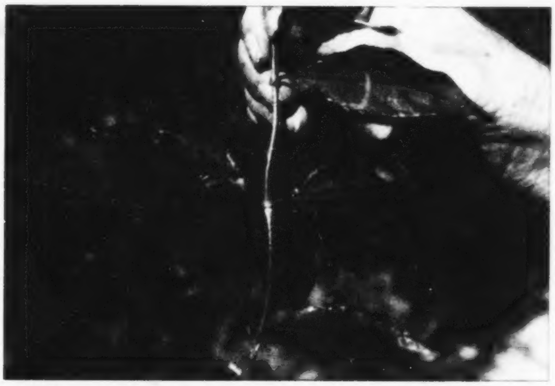

PLATE 18. *Septoria* leaf spot on *Cornus* sp., July.

PLATE 19. Brown, dead, persistent leaves as symptom of *Phytophthora* infection on *Contoneaster.*

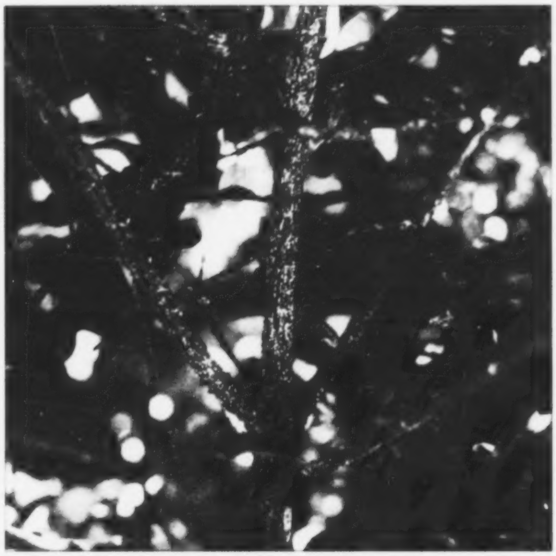

PLATE 20. Euonymus scale (*Unaspis euonymi*) adults appear as white and brown, oblong scales on twigs and leaf undersides.

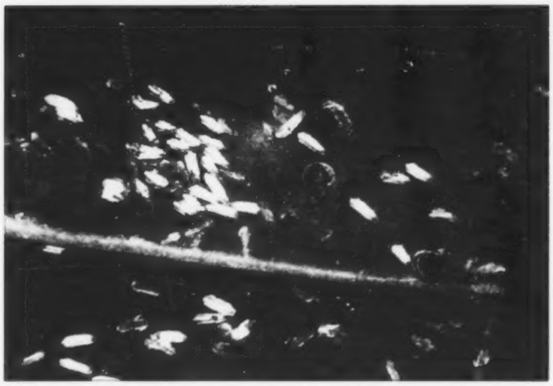

PLATE 21. Euonymus scale (*Unaspis euonymi*) adults on the lower leaf surface. Males appear white, females are oblong and brown.

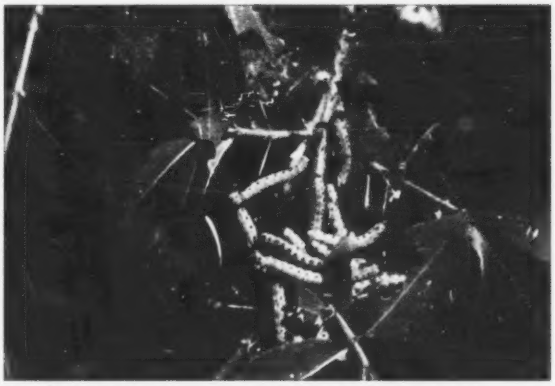

PLATE 22. Euonymus webworm (*Yponomeuta cagnagella*) larvae feeding, June.

PLATE 23. Stem dieback and cankers caused by Euonymus anthracnose (*Glomerella cingulata* or *Colletotrichum gloeosporioides*) on *Euonymus fortunei.*

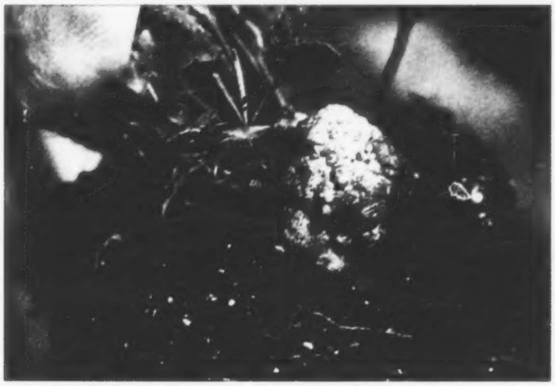

PLATE 24. A large crown gall (*Agrobacterium tumefaciens*) on *Euonymus.*

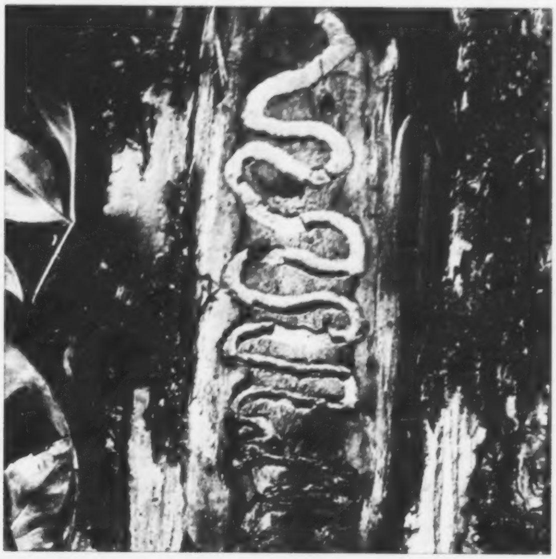

PLATE 25. Serpentine larval gallery caused by emerald ash borer (*Agrilus planipennis*) in the cambium of *Fraxinus pennsylvanica*.

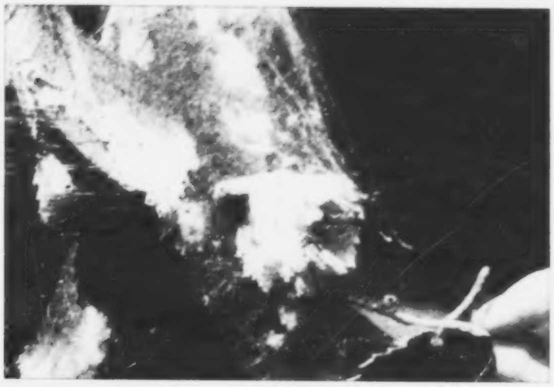

PLATE 26. Fall webworm (*Hyphantria cunea*) larvae feeding at end of branch, August.

PLATE 27. Bore hole and frass/sawdust at base of *Fraxinus pennsylvanica*, caused by Leopard moth (*Zeuzera pyrina*). Bore hole is ascending.

PLATE 28. Leopard moth larva (*Zeuzera pyrina*) in the heartwood of *Fraxinus pennsylvanica*.

PLATE 30. Honeylocust mite, plant bug and leafhopper damage causing stippling and bronzing of foliage.

PLATE 29. Anthracnose (*Gloeosporium aridum*) on ash causing malformed leaves with lesions at the edges.

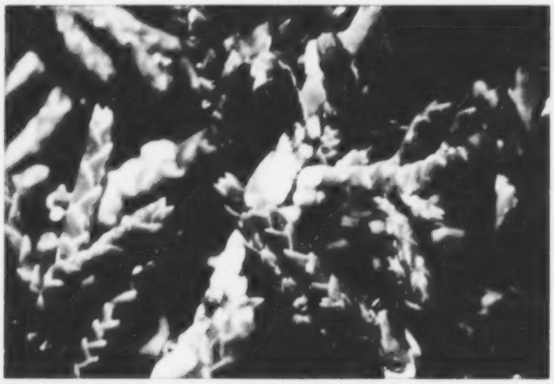

PLATE 31. Adult juniper scale (*Carulaspis juniperi*) with crawlers on foliage, late June.

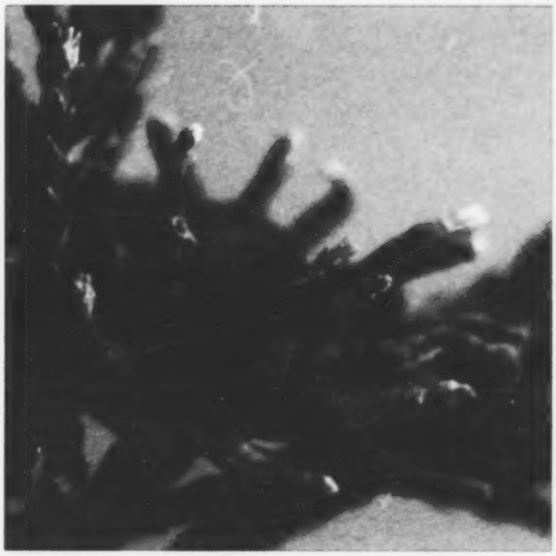

PLATE 32. Cedar-apple rust (*Gymnosporangium juniperi-virginianae*) overwintering gall on juniper foliage. Telia half emerged, May.

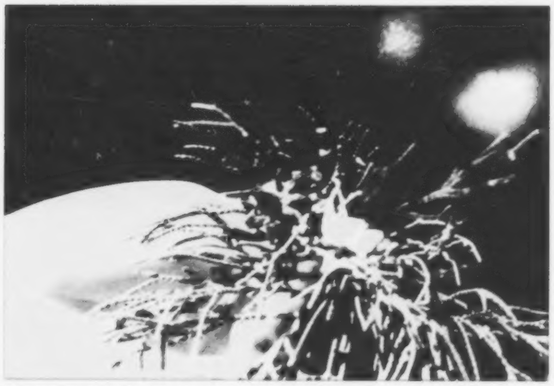

PLATE 33. Cedar-hawthorn rust (*Gymnosporangium globosum*) overwintering gall on juniper foliage, not sporulating, March.

PLATE 34. Juniper dieback or tip blight (*Kabatina juniperi*) on juniper showing pinched cankers at base of dead shoot.

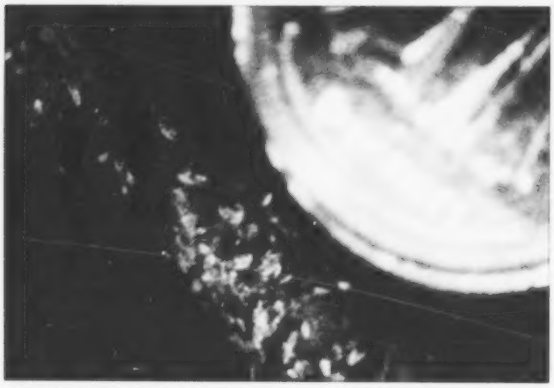

PLATE 35. Overwintering nymphs of *Magnolia* scale (*Neolecanium cornuparvum*) on the twigs of *Magnolia*, beside a Canadian dime, early May.

PLATE 36. Immature females of *Magnolia* scale (*Neolecanium cornuparvum*) on the undersides of twigs, July.

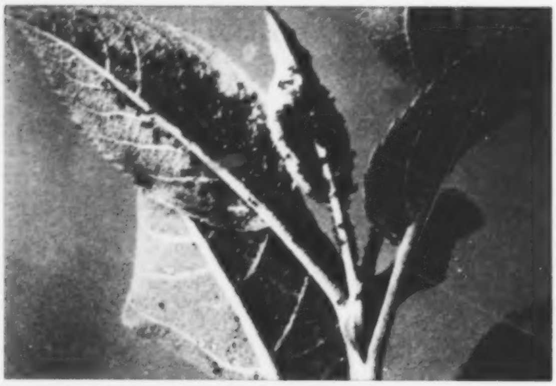

PLATE 37. Large aphid colony on *Malus* sp.

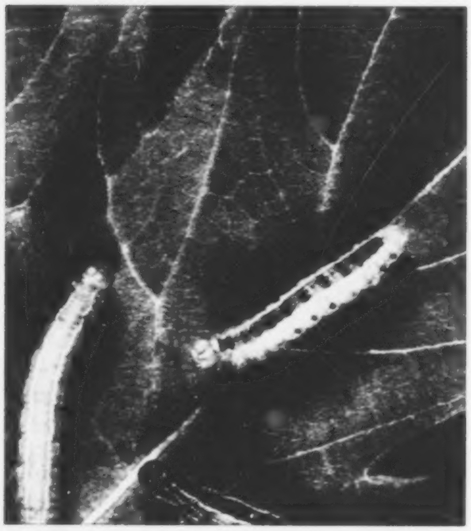

PLATE 38. Fall cankerworm (*Alsophila pometaria*) larvae, note various colour races.

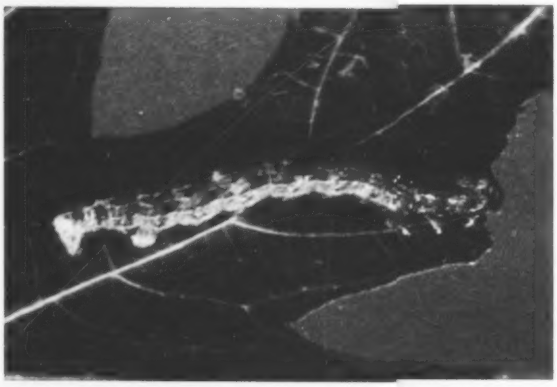

PLATE 39. Spring cankerworm (*Paleacrita vernata*) larva.

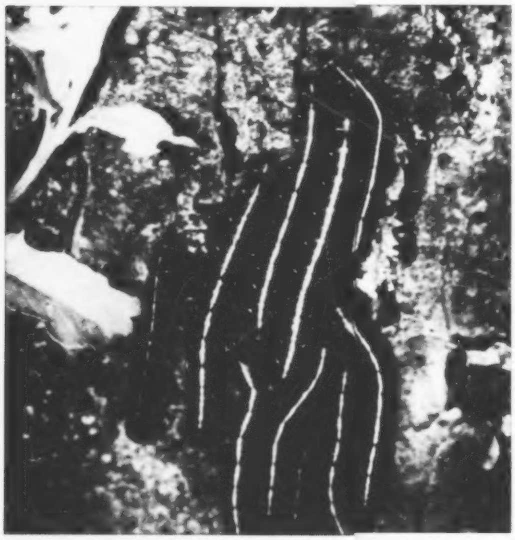

PLATE 40. Eastern tent caterpillar (*Malacosoma americanum*) larvae with a solid stripe along their back.

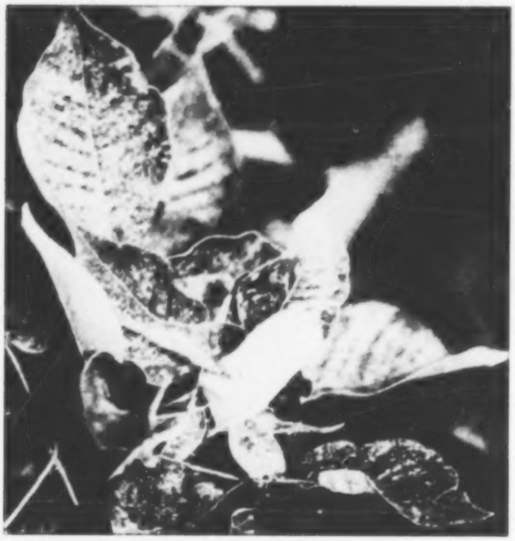

PLATE 41. Leafhopper "burn" or stippling damage on *Ptelea* sp.

PLATE 42. Fireblight (*Erwinia amylovora*) on *Malus* sp.

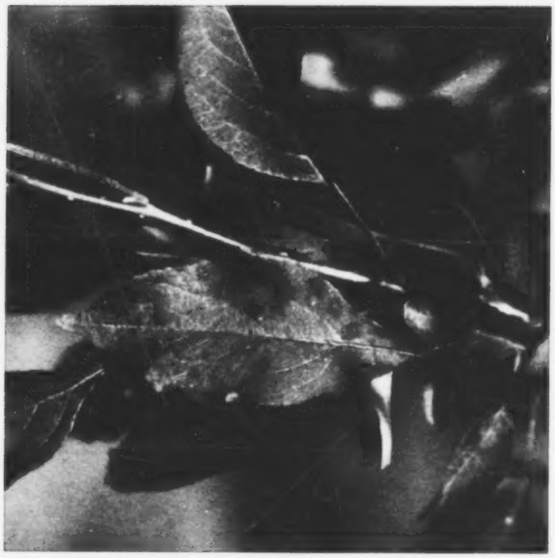

PLATE 43. Apple scab (*Venturia inaequalis*) on *Malus* sp.

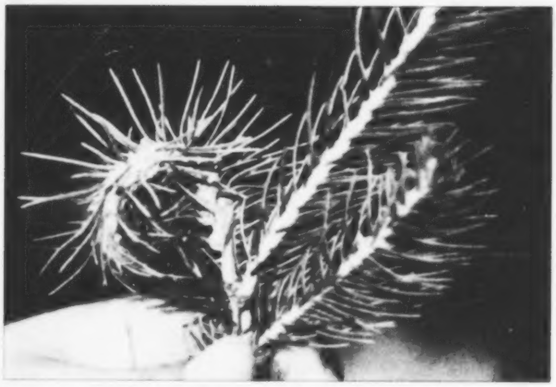

PLATE 44. Cooley spruce gall (*Adelges cooleyi*) formation on *Picea pungens* shoot tip, June.

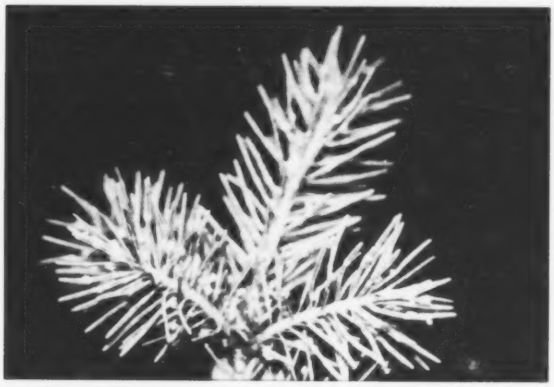

PLATE 45. Cooley spruce gall adelgids (*Adelges cooleyi*) feeding on *Pseudotsuga menziesii*, the alternate host, in May.

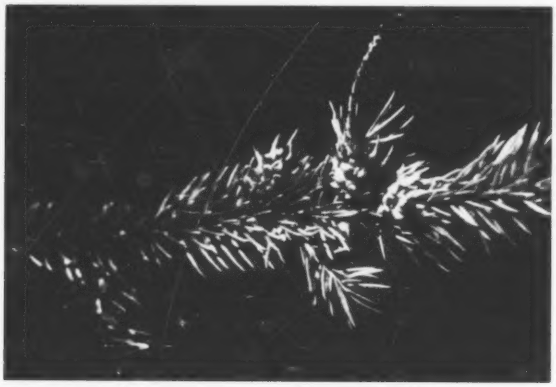

PLATE 46. Eastern spruce gall (*Adelges abietis*) formation on *Picea abies* shoot base, June. Galls resemble small pineapples.

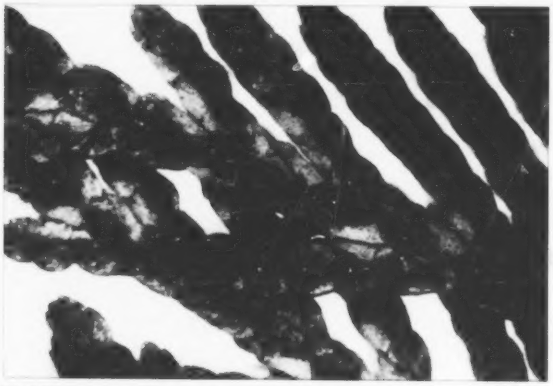

PLATE 47. Spruce spider mite (*Oligonychus ununguis*) feeding damage on *Thuja occidentalis*, September.

PLATE 48. Spruce needle miner (*Taniva albolineana* or *Endothenia albolineana*) feeding damage on *Picea* sp.

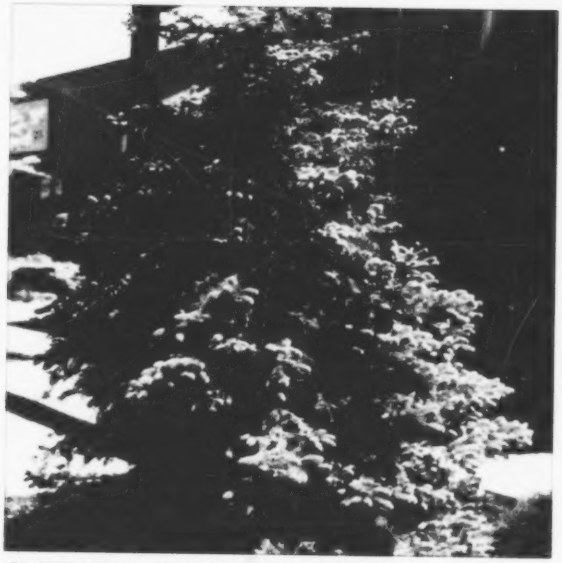

PLATE 49. *Cytospora* canker on *Picea*.

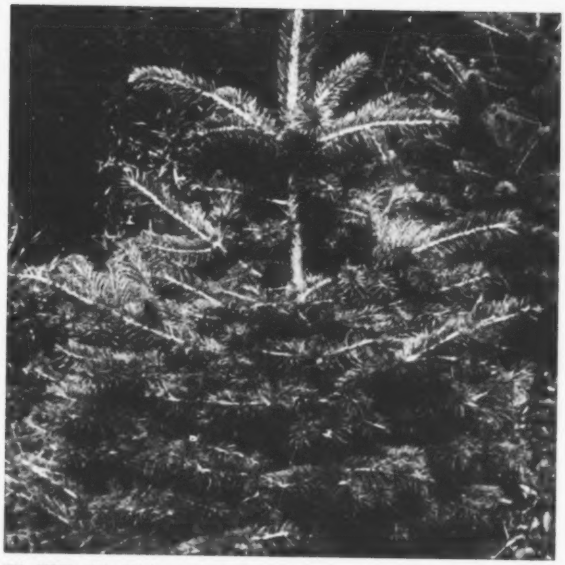

PLATE 50. *Rhizosphaera* needlecast on *Picea*, June.

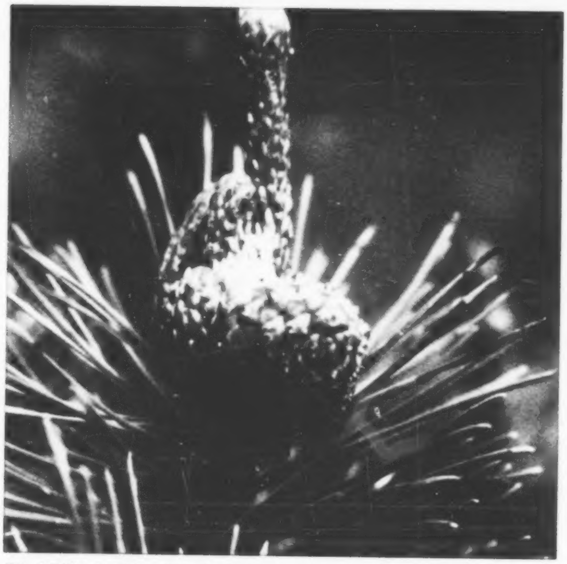

PLATE 51. Feeding damage on emerging shoots caused by European pine shoot moth (*Rhyacionia buoliana*), May.

PLATE 52. Feeding damage on *Pinus* by adult Pales weevil (*Hylobius pales*), September.

PLATE 53. Masses of pine bark adelgid (*Pineus strobi*) on the bark of *Pinus*, May.

PLATE 54. Adult pine needle scale (*Chionaspis pinifoliae*) gives a whitish appearance to foliage of *Pinus*, May.

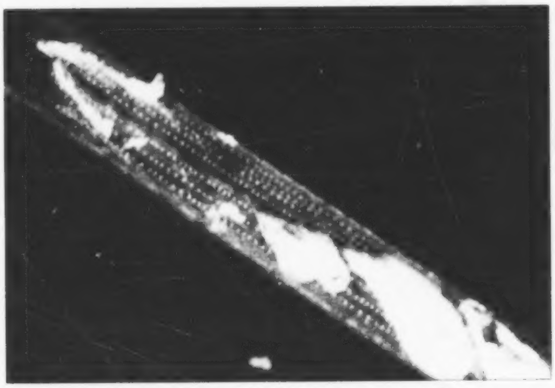

PLATE 55. Adult female pine needle scale (*Chionaspis pinifoliae*) with red crawlers, June.

PLATE 56. Pitch masses on bark of *Picea* due to feeding of pine pitch mass borer (*Vespamima pini*, *Synanthedon pini*).

PLATE 57. Pinkish white larva of pine pitch mass borer (*Vespamima pini*, *Synanthedon pini*) extracted from a pitch mass.

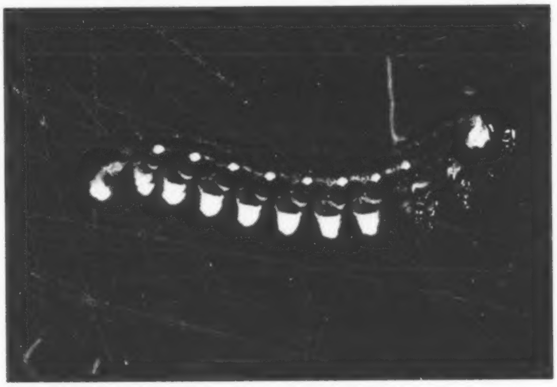

PLATE 58. European pine sawfly larva (*Neodiprion sertifer*).

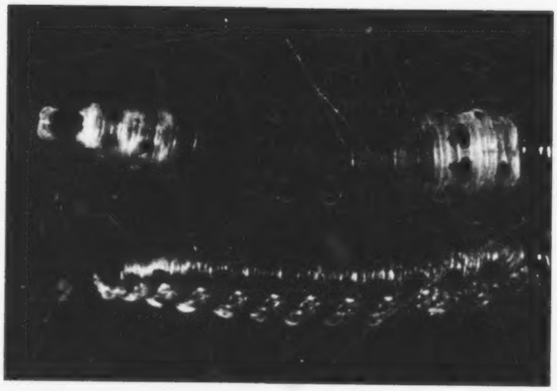

PLATE 59. Redheaded pine sawfly larvae (*Neodiprion lecontei*).

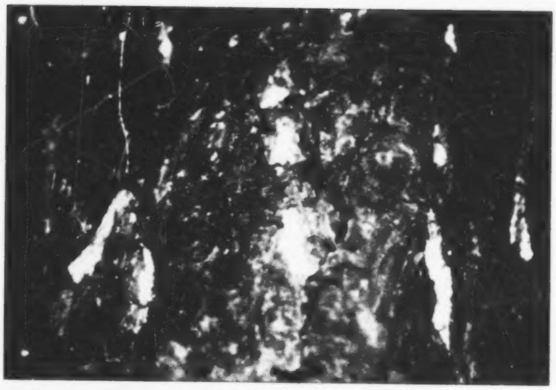

PLATE 60. Egg laying sites (sap streaks) in bark of *Pinus sylvestris* from the pine shoot beetle (*Tomicus piniperda*), early spring.

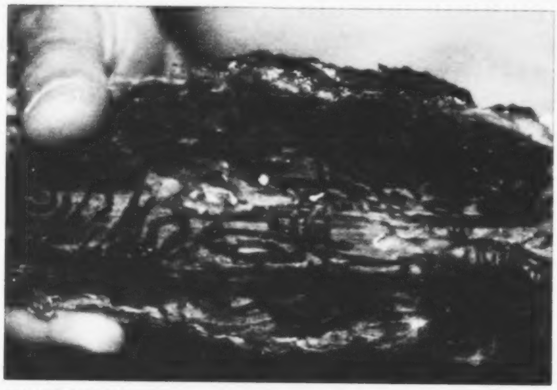

PLATE 61. Larvae and feeding galleries of pine shoot beetle (*Tomicus piniperda*) formed under bark of *Pinus sylvestris*.

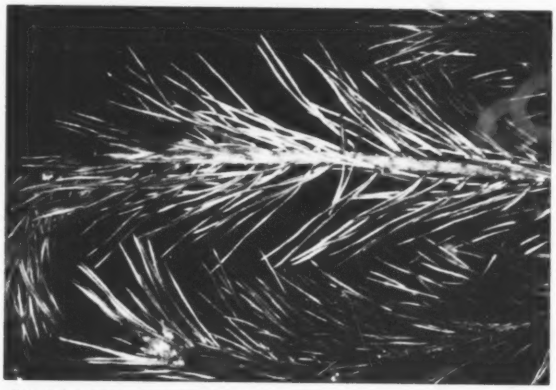

PLATE 62. Flagged/broken tip on *Pinus* sp. due to shoot feeding of adult pine shoot beetle (*Tomicus piniperda*).

PLATE 63. Adult pine shoot beetle (*Tomicus piniperda*) boring out a clean hole in the shoot tip of *Pinus* sp.

PLATE 64. Feeding damage on terminal caused by white pine weevil (*Pissodes strobi*).

PLATE 65. Legless, white larvae of white pine weevil (*Pissodes strobi*) inside terminal shoot, June.

PLATE 66. Stunted, dead new growth on *Pinus nigra* caused by (*Diplodia pinea* or *Sphaeropsis sapinea*) tip blight, June.

PLATE 67. Killed pine needles of previous year's growth due to *Lophodermium* needlecast.

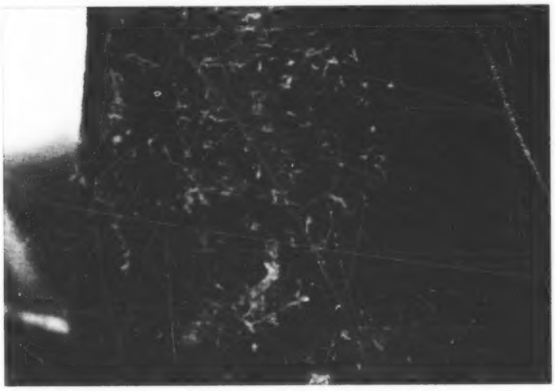

PLATE 68. Canker on main stem of *Pinus strobus*, showing white pine blister rust (*Cronartium ribicola*).

PLATE 69. Damaged limbs of *Prunus* sp. from larvae of lesser Peachtree borer (*Synanthedon pictipes*).

PLATE 70. Cankers and bark splitting caused by feeding of Peachtree borer larvae (*Synanthedon exitiosa*) on *Prunus x cistena* liners.

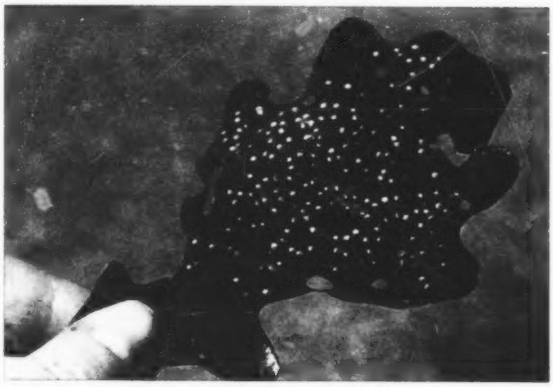

PLATE 71. One of the many types of oak leaf gall.

PLATE 72. Bore hole in *Quercus rubra* caused by an active larva of Red Oak Clearwing Moth (*Paranthrene simulans*).

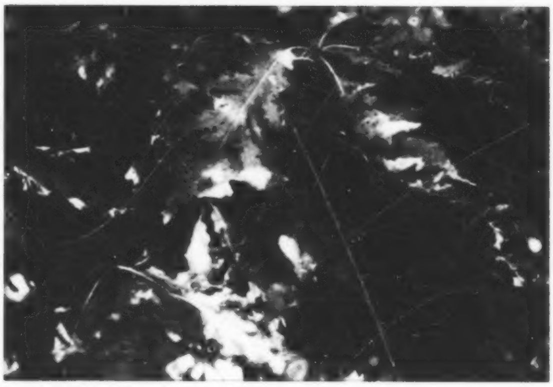

PLATE 73. Physiological leaf scorch on *Quercus rubra*, caused by heat and drought stress.

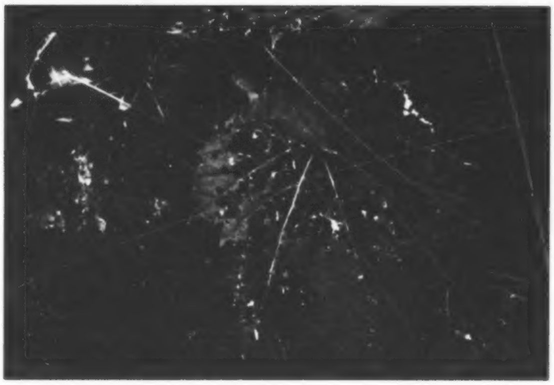

PLATE 74. Skeletonizing damage on *Vitis* sp. caused by Japanese beetle adults (*Popillia japonica*).

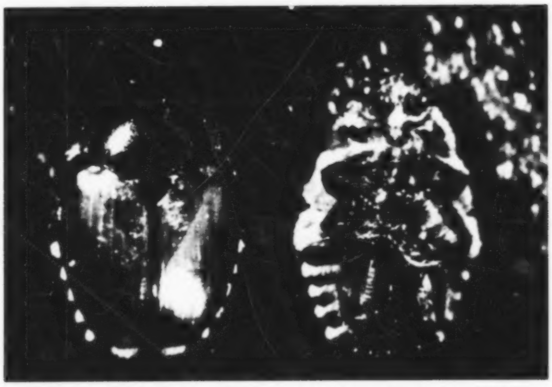

PLATE 75. Adult Japanese beetle (*Popillia japonica*), dorsal and ventral view. Note tufts of white hairs around abdomen.

PLATE 76. Black spot (*Diplocarpon rosae*) lesions on foliage of *Rosa* sp.

PLATE 77. Exit hole from emerging adult lilac borer (*Podosesia syringae*), June.

PLATE 78. Leaf blotches caused by feeding damage of lilac leafminer (*Caloptilia syringella*), June.

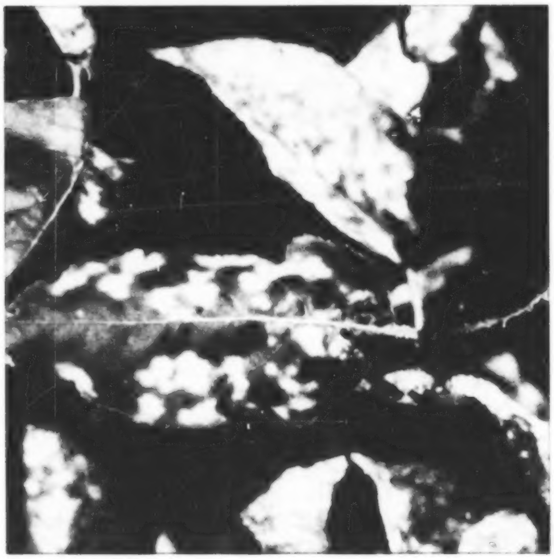

PLATE 79. Powdery mildew (*Microsphaera alni*) on *Syringa* sp., August.

PLATE 80. Notches in leaves of Rhododendron caused by feeding of adult black vine weevil (*Otiorhynchus sulcatus*).

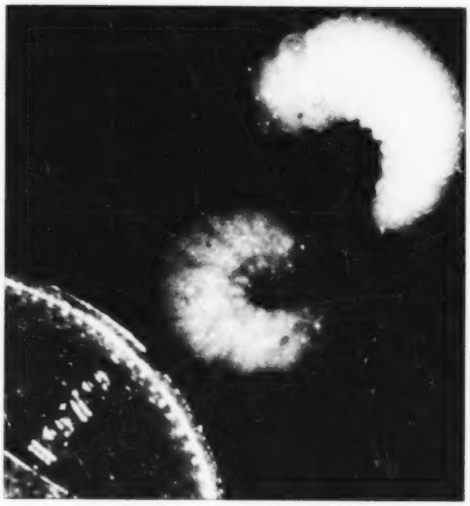

PLATE 81. Legless, white larvae of black vine weevil (*Otiorhynchus sulcatus*), beside a Canadian dime.

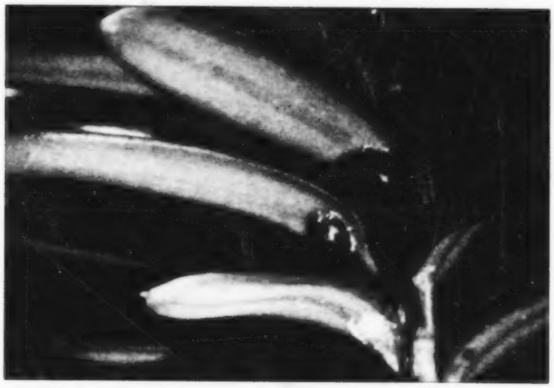

PLATE 82. Adults of Fletcher scale (*Lecanium fletcheri*) on twigs and leaves of *Taxus* sp.

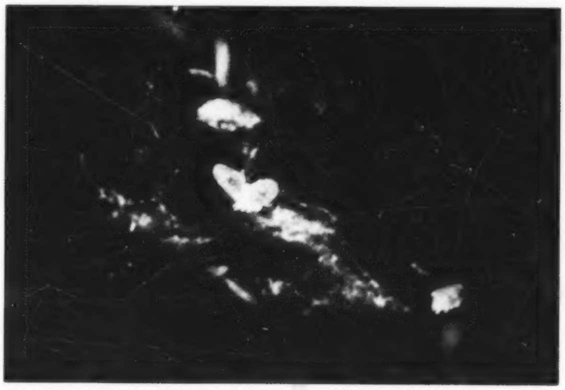

PLATE 83. Nymphs of *Taxus* mealybug (*Pseudococcus cuspidatae* or *Dysmicoccus wistariae*) on twigs, May.

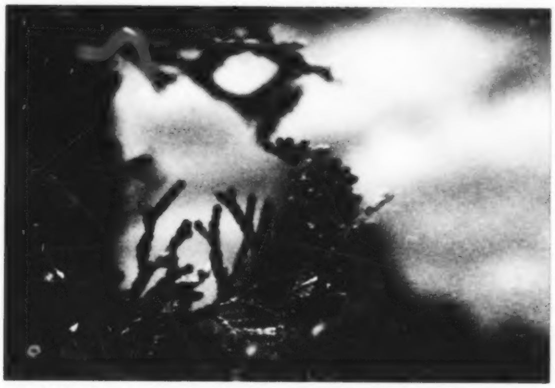

PLATE 84. Foliar tip browning caused by feeding of cedar leaf miner larvae (*Argyresthia thuiella* and other spp.), June.

PLATE 85. Foliar bronzing and some twig bark stripping on *Thuja occidentalis*, caused by strawberry root weevil (*Otiorhynchus ovatus*) adults.

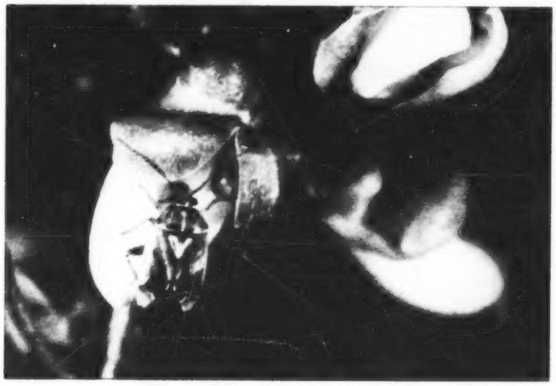

PLATE 86. Adult tarnish plant bug (*Lygus lineolaris*).

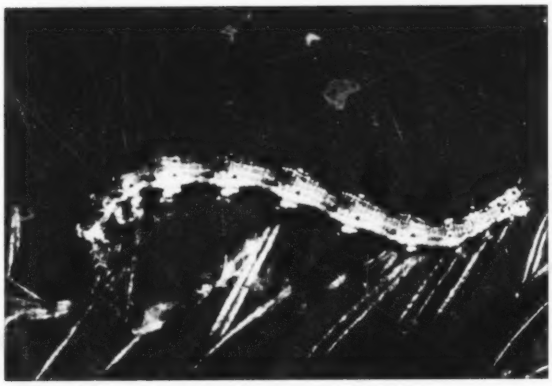

PLATE 87. Eastern hemlock looper (*Lambdina fiscelleria*) larva.

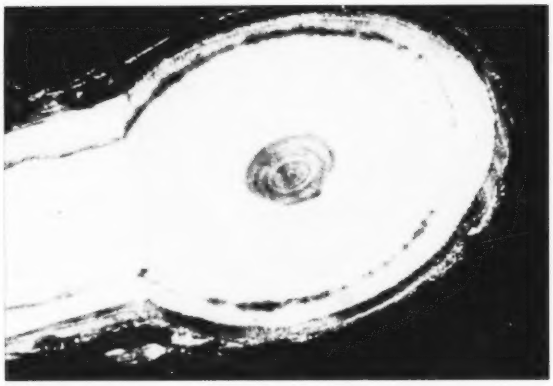

PLATE 89. Infection of xylem by Dutch elm disease (*Ceratocystis ulmi*) causes stained rings in wood.

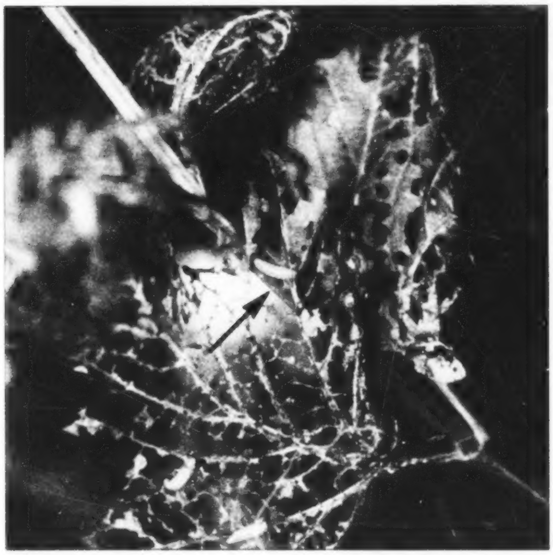

PLATE 91. Skeletonizing damage due to feeding of Viburnum leaf beetle (*Pyrrhalta viburni*) larvae, June.

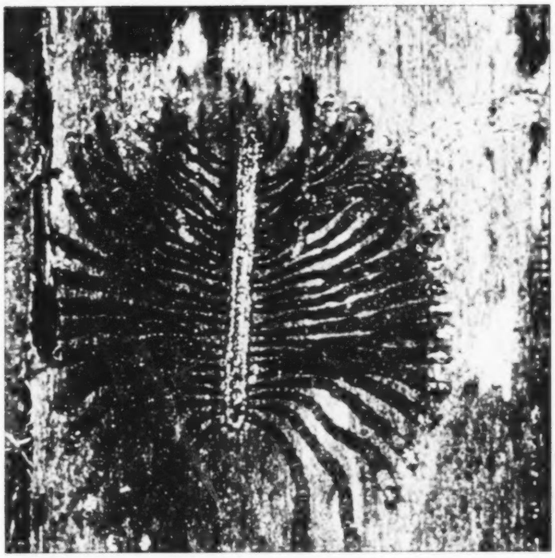

PLATE 88. Representative larval gallery of elm bark beetle (*Scolytus multistriatus, Hylurgopinus rufipes*) in cambium.

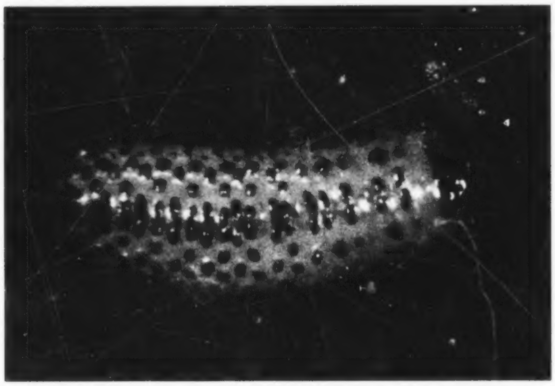

PLATE 90. Viburnum leaf beetle (*Pyrrhalta viburni*) larva, May.

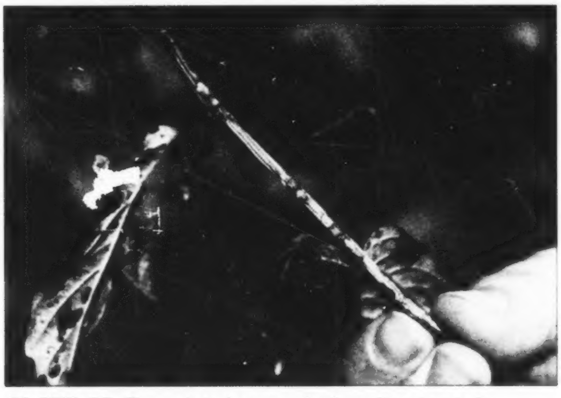

PLATE 92. Overwintering egg-laying sites (on twig undersides) of *Viburnum* leaf beetle (*Pyrrhalta viburni*), August.

The photos on these pages were provided by the University of Guelph, Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture and Food.

Emergency and First-Aid Procedures for Pesticide Poisoning

For a major spill, a theft or a fire involving a pesticide call the Ministry of the Environment at **1-800-268-6060.**

For pesticide poisonings and pesticide injuries call the Poison Information Centre:

Toronto	1-800-268-9017
Ottawa (Bilingual)	1-800-267-1373
Hearing Assistance (TTY)	1-877-750-2233

PREVENT ACCIDENTS

- **Read the label**. Follow all the precautions the label recommends. Read the First Aid section of the label BEFORE you begin to handle any pesticide.
- **Make sure that someone knows** what pesticides you are working with and where you are.
- **Keep a file of labels and product Material Safety Data Sheets (MSDS) for the pesticides you use**. Make sure everyone knows where to find this in case of an emergency.
- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.

If someone has been working with pesticides and you see any possible symptoms of pesticide poisoning or injury, take emergency action immediately.

IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the 4 basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
- Call an ambulance or the Poison Information Centre.
- Start first aid. This is not a substitute for professional medical help.
- **Provide the label, MSDS sheet or container to emergency personnel** at the scene — or take it with you to the hospital. Do not transport pesticide containers in the passenger compartment of the vehicle.

FIRST AID

If a pesticide comes in contact with skin:

- remove all contaminated clothing; wash skin thoroughly with lots of soap and warm water
- dry skin well and cover with clean clothing or other clean material.

If pesticide comes in contact with eyes:

- hold eyelids open wash the eyes with clean running water for 15 minutes or more.

If pesticide was inhaled:

- move the victim to fresh air and loosen tight clothing
- give artificial respiration if the victim is not breathing.

Do not breathe in the exhaled air from the victim — you could also be poisoned.

If a pesticide was swallowed:

- **call the Poison Information Centre IMMEDIATELY.**

Emergency numbers are listed at the front of each Bell telephone directory.

For information, or to obtain copies of this or any other ministry publication please: call 1-888-466-2372 from within Ontario, (519) 826-3700 from outside the province or OMAF's TTY line at (519) 826-7402 for the hearing impaired, email your request to *products@omaf.gov.on.ca*, or visit OMAF's Web site at *www.gov.on.ca/omaf*.

A complete list of all OMAF products and services, and order forms, are available on the Web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAF, 1 Stone Road West, Guelph, Ontario N1G 4Y2.

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